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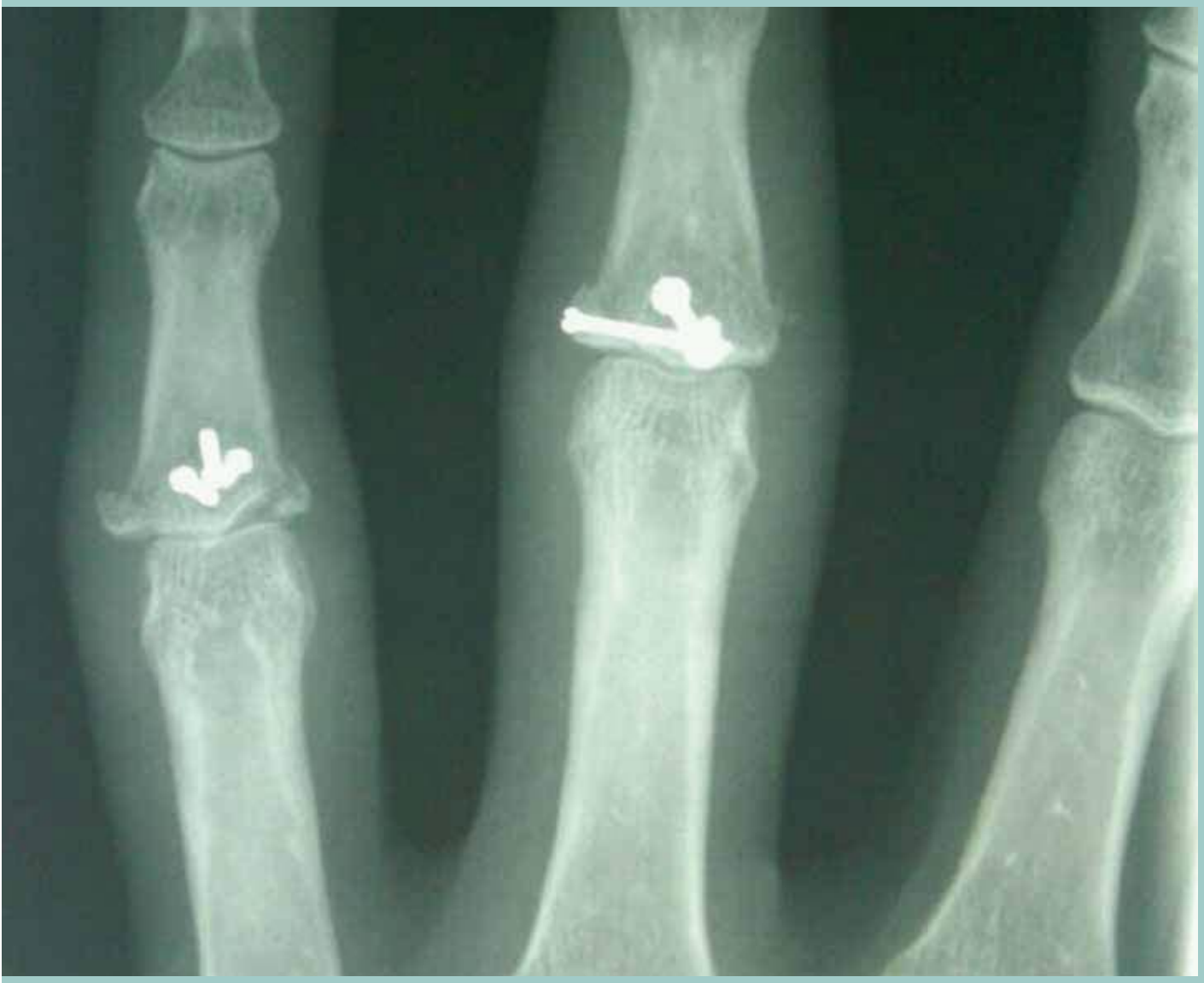


ORIF: PIP Fracture and Dislocation of the Fingers

Jeanne Rieger, CST

The Proximal Interphalangeal (PIP) joint is one of the most sensitive joints in the body. Due to its small size, as well as its proximity to structures such as the articular cartilage, volar plate and collateral ligaments, surgical reconstruction of the joint can be a very delicate procedure. Open reduction internal fixation is the preferred method of repair for this injury if it is serious enough to require surgery.

On a beautiful summer day in Indiana, a 50-year old grandmother of three was hanging out at the lake with some friends. They were taking turns on a rope swing—flying out over the water and dropping into the lake. The future patient took her turn, but when she let go to drop into the lake, her fingers became entangled in the rope. She came out of the water with the ring and middle fingers of her left hand dislocated and broken at the proximal interphalangeal (PIP) joint between the proximal phalanx and middle phalanx.

An initial X-ray at a nearby hospital revealed that the fingers were so badly broken that she would have to see an orthopedic surgeon to have them pinned and possibly plated. Normally, this type of procedure is performed by a plastic surgeon, who has completed a rotation in hand surgery. The patient chose to have her hand repaired at the Hand and Shoulder Center in Indianapolis.

After looking at the X-rays, the surgeon scheduled surgery for an open reduction internal fixation (ORIF) with screws and a possible plate. Because the fracture was through both the shaft of the bone and the articular surface of the joint, the surgeon noted

LEARNING OBJECTIVES

- Review the relevant anatomy for this procedure.
- Determine the factors that indicate if an injury should be treated surgically or nonsurgically.
- Evaluate the step-by-step process of reconstructing the PIP joint
- Examine the development of hand surgery as a specialized field
- Assess the possible risks and complications associated with this procedure

that it was one of the worst ways to have injured the fingers. According to the surgeon's nurse practitioner, who has been in the field for more than 14 years, this type of injury is especially traumatic due to the soft tissue injury combined with the small, bony joint fracture. This type of injury has increased potential for arthritis due to the interruption of the articular cartilage.

HISTORY

According to the *Journal of Hand Surgery,* Sterling Bunnell, MD, is considered the founding father of the specialty of hand surgery in the United States. Like many surgical specialties throughout history, advancements in hand surgery arose from necessity during wartime. Dr Bunnell's influence on Army medicine developed during and after WWII, when he served as a civilian consultant to the Surgeon General of the US Army, Norman T Kirk.

In 1944, Kirk was inspecting a plastic surgery center at Valley Forge General Hospital and noticed an abundance of "crippled hand" cases. He wrote a personal letter to Dr Bunnell requesting his assistance. On November 29, 1944, Bunnell was assigned "to guide, integrate and develop the special field of hand surgery" in the Army.[2] At the same time, he published *Surgery of the Hand,* which the Army adopted as an official text, distributing the book to all of its hospitals.[2]

Over the course of his visits to Army hospitals, Bunnell noted numerous cases in which improper traction, splinting and skin grafting resulted in less complete restorations of function than he believed possible. It was this realization that inspired him to improve the quality of treatment by bringing together specialists from the fields of orthopedic, plastic and neurosurgery to work on injured hands and qualify them in all three specialties. Bunnell recognized that the three fields of specialization were very closely woven, but that having three specialists working in such a small operative area was inefficient, if not impossible.

In pursuit of his vision, Dr Bunnell visited nearly all of the general hospitals in the United States. During his tour, he conducted 23 courses of three to four days each, including presenting operative demonstrations as part of the course. At the same time, Dr Bunnell urged the formation of a hand-surgery unit in each hospital.

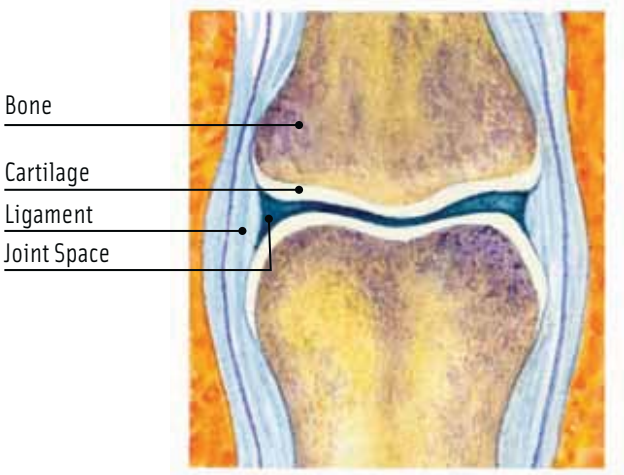
After completing his tour with the Army, Dr Bunnell was appointed as a teaching consultant in hand surgery at Letterman Army Hospital in San Francisco. In the words of Surgeon General Kirk, "[Bunnell's] tours of duty were made at heavy personal sacrifice and without regard to his own interests. The result was the achievement of functional results in surgery of the hand hitherto believed beyond attainment."[2]

Many of the practices taught by Dr Bunnell were carried back into civilian practice after the end of the war and have continued to evolve and develop to this day.

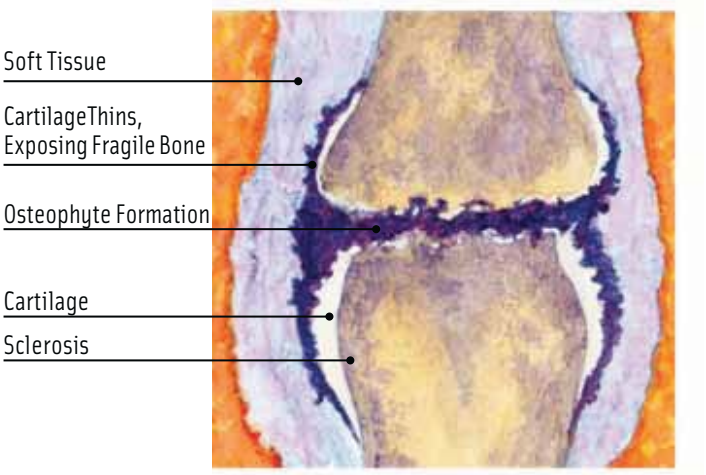
ANATOMY

The PIP joint is one of the most unforgiving joints in the body to injure. A simple sprain of the PIP joint can result in a painful and stiff finger that makes it difficult to perform simple actions such as gripping objects.[1]

The joints in the fingers are hinge-like, bending and straightening with a limited range of motion. The main



NORMAL PIP JOINT



TRAUMATIC ARTHRITIS

INSTRUMENTS

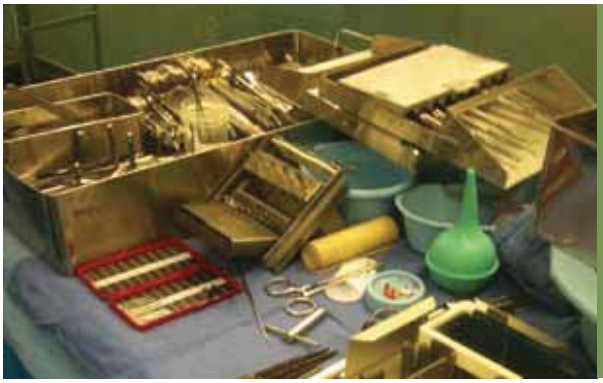
Synthes Modular Hand Set, including:
Drill bits
Countersinks
Screwdriver blades
Bending/cutting pliers
Universal pliers
Periosteal elevators, straight and curved
Sharp hooks
Plate- and screw-holding forceps
Hohmann retractors
Coupling handles
Cruciform screwdriver
Depth gauges
Reduction forceps
Termite forceps
Universal drill guide
Screws and plates of various sizes
Tenotomy scissors
Gelpi retractors
Bone rongeurs
Mosquito clamps
Skin hooks
Knife handles
Senn retractors
Cricket retractors
K-wires of various sizes
Stryker 4200 drill

EQUIPMENT

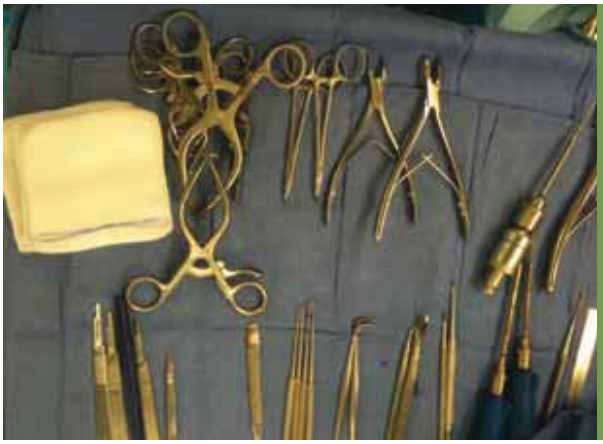
Tourniquet
ESU
Hand table
Power source for instruments

SUPPLIES

Extremity pack
Hand towels
Laps
Cleaning wipes
4" Esmarch bandage
#15 blade
Prep set
Mini C-arm drape
Gowns and gloves
Basin Set
Suture



Back table with K-wires.



Mayo stand for ORIF.

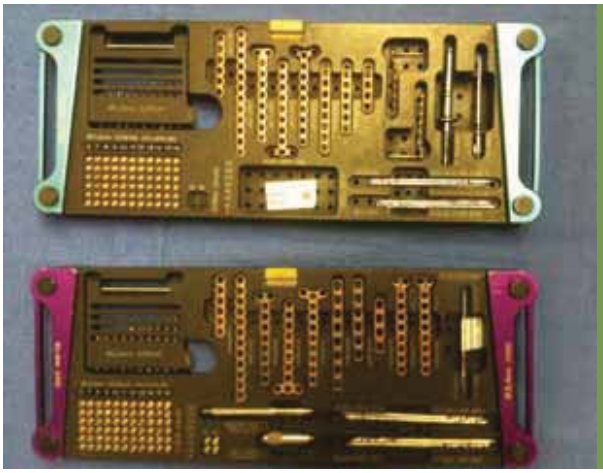


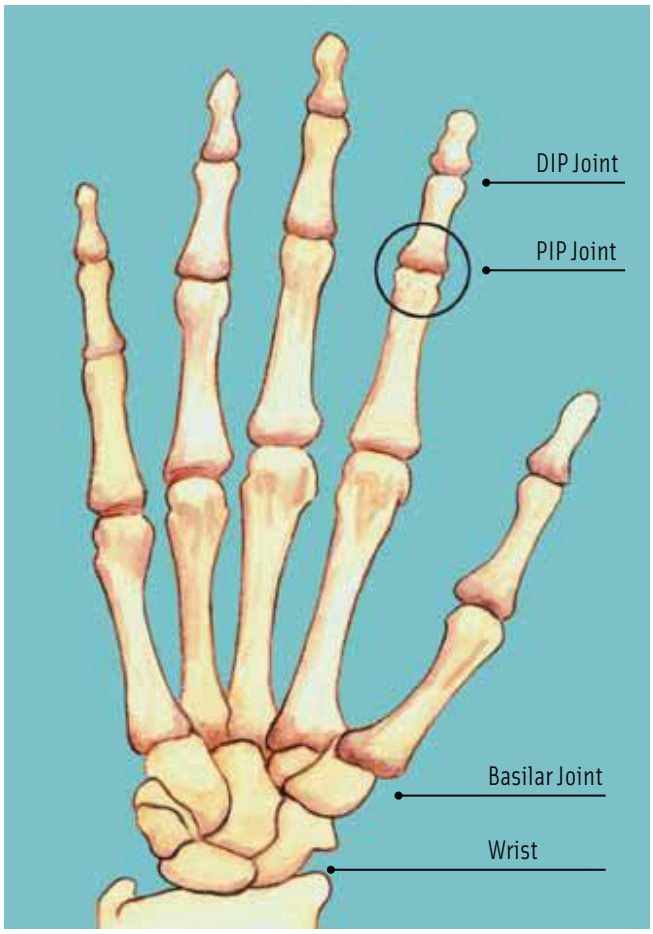
Plate and screw set.

Synthes Modular hand set.

knuckle, the metacarpophalangeal joint (MCP) is formed by the connection of the metacarpal bone in the palm of the hand with the phalange. The second, third, fourth and fifth fingers are composed of three phalanges, which are separated by two interphalangeal (IP) joints. The one closest to the MCP joint is the PIP joint.

Several ligaments hold the joints together. In the PIP joint, the volar (toward the palm) plate is the primary ligament. A ligament where it originates, the volar plate is cartilaginous where it inserts. It connects the proximal phalanx to the middle phalanx on the palm side of the joint. The ligament tightens as the joint is straightened and prevents it from being hyperextended. The PIP joint is also sandwiched between two collateral ligaments, which tighten when the joint is stressed laterally, helping maintain stability.

One of the most common injuries to the PIP joint is a sprain, typically indicating that a ligament has been stretched and possibly partially torn. If a ligament is stretched too far, it can rupture. Injury to the volar plate can occur with the joint is hyperextended. If torn completely, the ligament usually ruptures or is torn away from its attachment on the middle phalanx. In some circumstances, this may result in a small bone avulsion from the middle phalanx. When the avulsion is small, it may not be a big concern, however, if it involves a significant amount of the joint surface, it may require surgery to repair the fragment and restore the joint surface.[1]



The collateral ligaments can be damaged if the joint is stressed laterally, causing the ligament to rupture. These ligaments can also be injured if the PIP joint is dislocated, with the middle phalanx dislocating behind the proximal phalanx.[1]

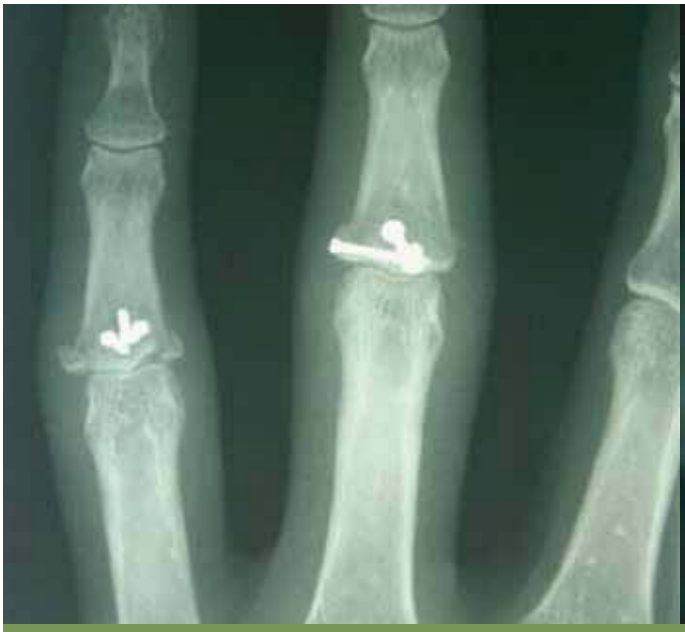
DIAGNOSIS AND TREATMENT

In most cases, damage to the joint will be immediately evident. Pain and swelling at the suspected injury site is common, and the finger will appear physically deformed if the joint has been completely dislocated. X-rays are required to determine if there is an avulsion fracture associated with the injury, as well as to determine if the alignment of the joint after an injury or after the reduction of a dislocation. If an avulsion is present, it may alter the surgeon's recommendation for treatment.

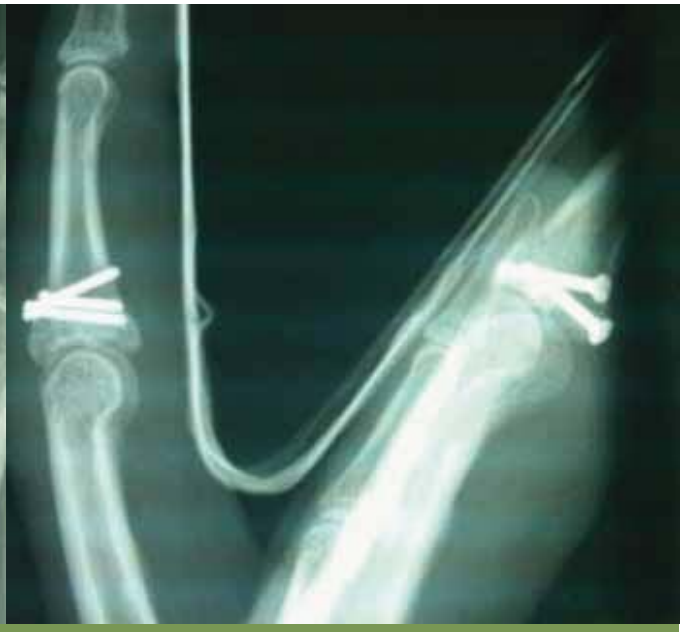
Nonsurgical treatment is suggested for the majority of injuries to the PIP joint. It is critical to begin rehabilitation exercises shortly after injury because the PIP joint is very sensitive and can become stiff very rapidly when it is immobilized, even for short periods of time. The sooner the joint begins to move, the less likely there will be any problems with flexibility in the future.[1] A short period of splinting is advised, followed by taping the injured finger to an adjacent finger. This allows the uninjured finger to brace the injured one, while simultaneously bending and moving with the uninjured finger as the hand is used normally.

Even if the joint has been totally dislocated or the volar plate has been ruptured, nonsurgical treatment is often still advised. Like a simple sprain, the goal is to keep the joint stable while beginning to move it as soon as possible. Since this injury is a result of hyperextension of the joint, a dorsal blocking splint is used to prevent full extension, while still allowing some movement. The brace is normally used for three to four weeks, allowing the ligament to heal enough to stabilize the joint.

In more severe cases, the volar plate may be caught in the joint, preventing the surgeon from reducing the joint without surgery.[1] Surgery may also be necessary to repair



Superior X-ray of two ORIF-repaired PIP joints.



Lateral X-ray of two ORIF-repaired PIP joints.

extensive damage to the collateral ligaments and volar plate, which is the case in this study.

OPEN REDUCTION INTERNAL FIXATION

Open reduction internal fixation (ORIF) is usually completed in two stages. First, the broken bone is reduced, specifically, a reduction by manipulation of the bone after surgical exposure at the site of the fracture. Second, an internal fixation device is placed on or in the bone. Internal fixation devices for this type of procedure can include screws, plates, rods and pins to hold the segments of the broken bones together.

PROCEDURE

The patient is moved into the operating room, where an axillary block and one gram if intravenous cefazol is administered. Cefazol is a preventative antibiotic that is regularly used when pinning or plating bone. The operative arm is prepped and draped with split drapes. The operative arm is exsanguinated with an esmarch bandage and a proximal well-padded tourniquet is inflated to 250 mmHg.

A volar approach is made to the middle finger and a Bruner incision is made with sharp dissection down through the skin and subcutaneous tissue. The neurovascular bundle is identified and sharp dissection is used to elevate a full-thickness flap. Once the surgeon reaches the tendon sheath, it is resected and the flexor digitorum superficialis (FDS) is split. The volar plate is released distally and the collateral ligaments are recessed. The joint is then able to be "shot-gunned," exposing the articular surface. The term "shot gun" refers to the way the finger is manipulated for surgery. It has the appearance of a shot gun that is cracked at the breech to be loaded.

In this case, a hematoma is irrigated and removed with a curette. Visualization of the joint surface at the base of the middle phalanx reveals that it is broken in three pieces. The surgeon reduces the joint anatomically and provisionally holds the pieces in place with K-wires. Multiple 1.0mm and 1.3mm self-tapping titanium cortex screws are then used to perform a definitive fixation.

It should be noted that the fixation must be stable, and passive range of motion must be congruent. The surgeon must check to determine if the joint has any tendency to subluxate. There should be no crepitiation or grinding. Intraoperative fluoroscopy will confirm the anatomic reduction and the position of the implants. The skin is then irrigated. The volar plate is reattached with 4-0 braided nylon suture on a P10 needle. The tendon sheath is repaired with 6-0 nylon on a P10 needle, and the skin is closed with 4-0 polypropylene suture on a P12 needle.

In this case, the ring finger, which was also injured in the fall from the rope swing, is able to be satisfactorily

Significant swelling due to two broken PIP joints.

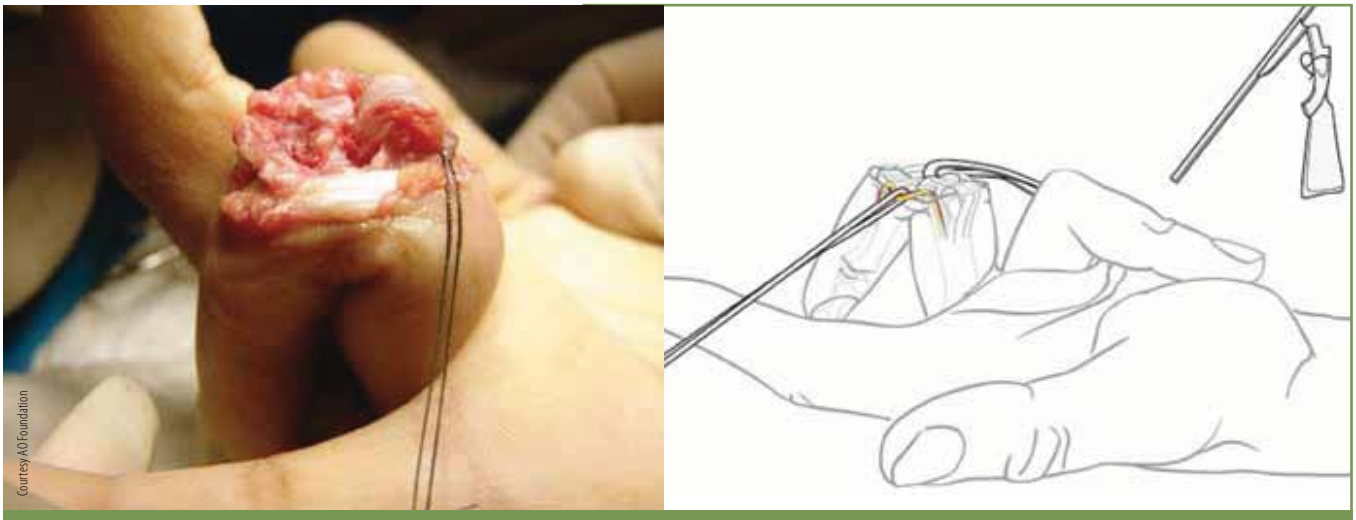
aligned with closed reduction, which allows a dorsal incision to be made. The triangular ligament is split, the fracture is identified and any hematoma is removed. Provisional fixation with K-wires is performed and three 1.0 mm screws are used to perform the definitive fixation. Again, intraoperative fluoroscopy confirms that the fixation is stable and the joint motion is smooth. The triangular ligament is reapproximated with 4-0 braided nylon suture on a P10 needle, and the skin is closed with 4-0 polypropylene suture on a P12 needle.

The tourniquet is deflated and a sterile dressing is applied. The sterile dressing in this case includes a volar splint with a bulky bandage to apply pressure.

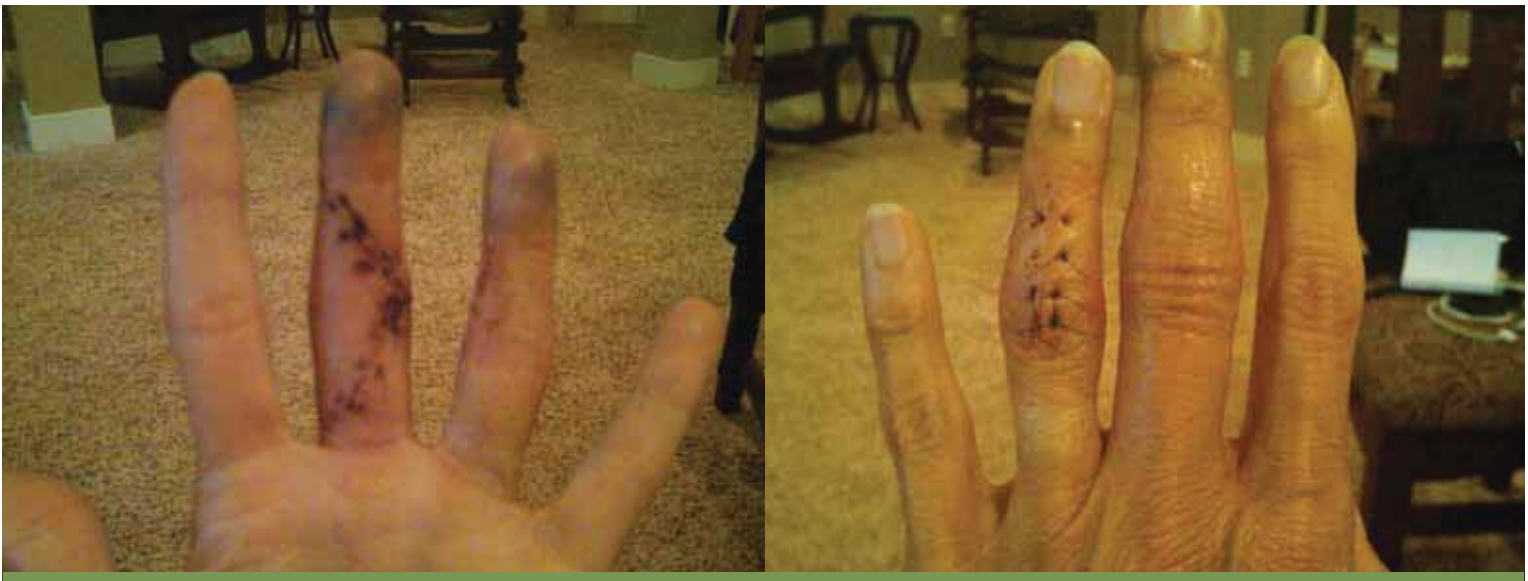
POSTOPERATIVE

The patient begins a supervised occupational and physical therapy program starting six days postoperatively. The therapy sessions are consistent for two to three months. A full recovery can take up to four months. Initial visits to the therapist focus on controlling pain and swelling at the operative site. This is followed by gentle range-of-motion exercises. Initial work in achieving movement of the joint is critical because of its predisposition to becoming stiff when immobilized for prolonged amounts of time.

Over time, strengthening exercises will be prescribed on a graduating scale as the joint heals. The exercises are



Shotgunning the finger allows the surgeon complete access to the joint.



A Brunner Incision is used to access the joint.

prescribed in an order that will protect the operative area from being stressed too much too soon.

The treatment of PIP fractures has very few contraindications. However, complications may arise if internal fixation is placed in either infected wounds or clean wounds that cannot be closed. If internal fixation is the chosen course of treatment in a wound that cannot be closed, any soft tissue defects should be immediately reconstituted by means of soft tissue mobilization or transposition at the time of the procedure.[1]

ABOUT THE AUTHOR

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2. Kirk N. "Sterling Bunnell." *J Bone Joint Surg Am.* 1958. Vol 40, No 2:488-490.

Microbiology Review

PATHOGENS AND DISEASE

Teri Junge, CST, CSFA, FAST, BS

Editor's Note: This article presents a brief overview of basic microbiology concepts and serves as an introduction to microbiology for surgical technology students, a review for practicing surgical technologists, and an exam preparation tool for individuals planning to take the national certification exam. It is not a comprehensive review.

ORGANISM CLASSIFICATION

The organism classification system, also called biological classification or scientific classification, is a method for grouping and categorizing organisms by biological type. The current system, developed by Carl Linnaeus, a Swedish botanist/medical doctor in the 1700s, is currently under review; changes in the nomenclature (rules for naming) and taxonomy (practice and science of classification) are likely. The Linnaean system is a hierarchal structure that utilizes the following terms for identification of all organisms.

Domain
Kingdom
Phylum
Class
Order
Family
Genus
Species

Several mnemonics are available to assist the learner in remembering the Linnaean classification system. For example, "**D**o **k**ings **p**lay **c**hess **o**n **f**ine **g**rained **s**and?"

LEARNING OBJECTIVES

- Explain the organism classification system and describe how organisms are classified.
- Name the main structures of an animal cell and describe the function of each.
- Describe the composition, location, and function of DNA within a cell.
- Explain the function of the three types of RNA within a cell.
- List and describe the stages of mitosis.
- Define meiosis.
- Describe passive and active methods by which substances enter and exit cells.
- List five types of microorganisms that cause harm to humans, identify the characteristics of each type of organism, and provide at least one example of a disease caused by each organism.
- Outline the infectious process and list the methods by which the human body is protected from infection.
- Understand the immunologic defense mechanism and provide examples of the different types of immunity.

STRUCTURE AND FUNCTION OF AN ANIMAL CELL

All living organisms are composed of cells that contain information that regulate cell functions and transfers information to the next generation of cells. The components of a cell include a nucleus, cytoplasm and plasma membrane.

The cell membrane is the outer covering of the cell. It is also called the plasma membrane or plasmalemma. The cell membrane consists of a double phospholipid layer that contains proteins and carbohydrates. Phospholipids allow free passage of water molecules through the cell membrane via osmosis. The cell is either hydrophilic (attracts water) or hydrophobic (repels water). Some proteins in the cell membrane allow passage of molecules and ions via transport channels or by active transport, while other proteins act as receptor sites and identity markers.

The protoplasm is the liquid portion of the cell. The portion of protoplasm that is inside of the cell membrane, but outside of the nucleus is called the cytoplasm. The main constituent of cytoplasm is water that contains chemical compounds (*eg,* mineral salts) in solution and organic compounds in colloidal suspension. The cytoplasm also contains organelles, storage granules, fat droplets and vacuoles.

A vacuole is an area within the cytoplasm that is surrounded by a membrane filled with a watery mixture of nutrients or waste products.

The mitochondria are considered the powerhouses of the cell. They are composed of two membranes. The outer membrane is shaped in a capsular form, and the inner membrane folds into itself to increase surface area. The folds are called cristae. The aerobic phase of cellular respiration occurs in the mitochondria.

Lysosomes are small structures in the cytoplasm that contain powerful digestive enzymes. Lysosomes perform three important functions.

- They work with food vacuoles to digest stored food.
- They provide maintenance and repair of other organelles and are the building blocks of protoplasmic structures.
- They destroy old or weakened cells.

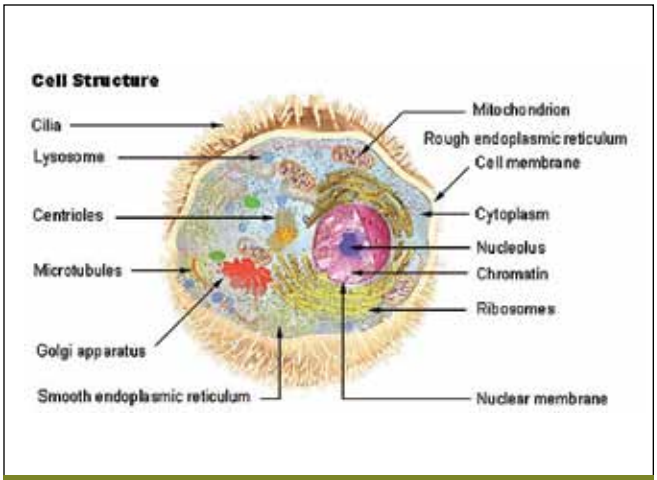
The endoplasmic reticulum (ER) is a complex system of membranes that make up channels called cisternae, which connect the outer nuclear membrane with the cell membrane. ER exists in two forms: rough and smooth. All cells have a rough ER, which has attached ribosomes that synthesize protein. Only certain cells have a smooth ER, which transports fat or synthesizes sex hormones.

The Golgi apparatus, also called Golgi body, is a collection of flat, sac-like cisternae that store compounds secreted by the cell and aid in the synthesis of necessary substances, such as carbohydrates.

Ribosomes are small granules distributed throughout the cytoplasm and are attached to the ER. Protein synthesis occurs in the ribosomes.

Centrioles are found in pairs. The centrioles form microtubules that assist in cell division.

The nucleus is the control center of the cell and contains the genetic material. The nucleus is surrounded by a membrane called the nuclear membrane. The nuclear membrane



Anatomy of an animal cell.

is a porous double membrane that allows passage of materials (*eg,* messenger RNA) to the cytoplasm. The inner layer of the nuclear membrane surrounds the nucleoplasm, which is the protoplasmic portion of the nucleus, and the outer layer connects with the endoplasmic reticulum. The nucleolus is a spherical particle within the nucleoplasm that produces ribosomes.

Chromatin contains the genetic material within the nucleoplasm. Chromatin consists of darkly stained threads of nucleic acids. The chromatin duplicates, shortens, and thickens during cell division and becomes visible as chromosomes.

DNA

DNA (deoxyribonucleic acid) is composed of two strands (double-helix structure) of alternating sugars and phosphates with four protruding nitrogenous bases (adenine, cytosine, guanine and thymine provide the DNA sequence). DNA is secluded from the rest of the cell within the nucleus for protection and contains the genes necessary for cell

reproduction. Genes contain all of the hereditary information for the cell and are organized into chromosomes.

RNA

RNA (ribonucleic acid) is involved with protein synthesis for all cells and carries genetic information for reproduction of certain viruses. There are three types of RNA.

Ribosomal RNA (rRNA) is involved in translation of the genetic message into a protein and along with that protein makes up the ribosomes, which are the site of protein synthesis.

Transfer RNA (tRNA) works with other types of RNA to transfer genetic information to proteins and carries an amino acid that may be used to build a protein at the ribosome.

Messenger RNA (mRNA) is built on a strand of DNA and transcribes the nucleotide code. Messenger RNA moves to the cytoplasm and attaches to a ribosome to allow for protein synthesis.

MITOSIS

Mitosis is the process of cell division when two duplicate cells result. Mitosis is a four-stage process with a resting/functional phase in between divisions.

Prophase. The DNA coils, the nucleolus and nuclear membrane begin to disappear. The centrioles move toward opposite ends of the cell and spindle-shaped fibers form in between.

Metaphase. The chromosomes line up across the center (equator) of the cell and attach to the spindle fibers.

Anaphase. The centomere splits, and the duplicated chromosomes separate and move toward opposite ends of the cell.

Telophase. The membranes appear around each group of separated chromosomes, forming two new nuclei completing division of the cell.

The resting/functional phase in between cell divisions is called interphase. During interphase, the cell functions normally and prepares for mitosis.

MEIOSIS

Meiosis only applies to the formation of the sex cells (sperm and ovum). During meiosis, the number of chromosomes are cut in half.

PASSIVE AND ACTIVE TRANSPORT

For cells to function properly, it is necessary for materials, such as nutrients and oxygen to be able to enter the cell, and the products of cell activity, such as hormones, neurotransmitters, digestive enzymes, and waste products to be able to exit the cell. Passive and active transport are the two main methods by which materials enter and exit the cell.

Passive Transport

Passive transport uses no energy, and the substances move from an area of high concentration to an area of low concentration. There are four types of passive transport.

- Diffusion. Substances move through a medium, such as air or a permeable membrane.
- Osmosis. This particular type of diffusion requires passage of a substance through a semi-permeable membrane.
- Filtration. A substance passes through a membrane, using force such as pressure or gravity.
- Facilitated diffusion requires use of a transporter.

Active Transport

Active transport uses energy in the form of adenosine triphosphate (ATP), and the substances move from an area of low concentration to an area of high concentration.

Endocytosis is bulk movement of materials into the cell. Phagocytosis, receptor-mediated phagocytosis, and pinocytosis are examples of endocysotis. During phagocytosis, large particles are engulfed by the plasma membrane and moved into the cell. During receptor-mediated phagocytosis receptors on the cell surface detect specific molecules and allow rapid movement of the molecule into the cell. During pinocytosis, fluid droplets are engulfed by the plasma membrane and moved into the cell.

Exocytosis is bulk movement of materials out of the cell. During exocytosis, vesicles are employed as transporters.

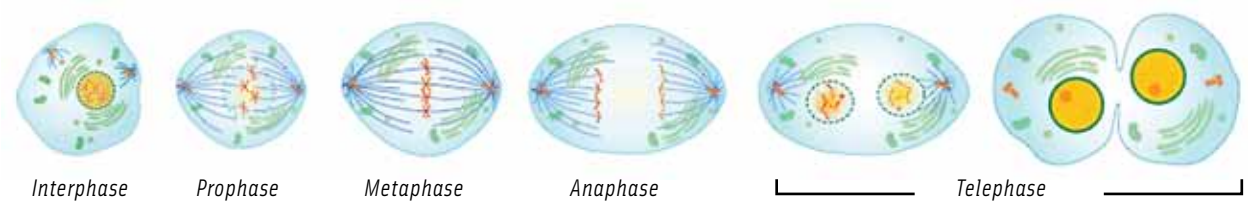


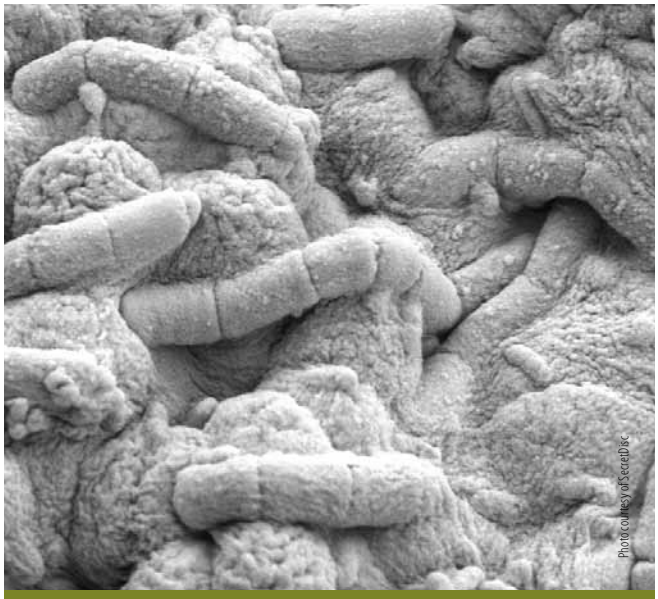
TABLE 1- CHARACTERISTICS OF BACTERIA	
Aerobic – requires oxygen to sustain life	**Anaerobic** – capable of living without oxygen
Motile – capable of spontaneous movement; usually due to the presence of flagella	**Nonmotile** – not capable of movement
Free-Living – capable of making their own food; not dependent	**Commensal** – dependent on another organism for food; the relationship is not harmful to either organism
Saprophytic – requires dead or decaying organic matter to sustain life	**Parasitic** – requires live organic matter to sustain life; the relationship is often harmful to the host
Pathogenic – capable of producing disease	**Beneficial** – advantageous; such as normal flora

TYPES OF MICROORGANISMS THAT CAUSE HARM TO HUMANS

There are five main types of microorganisms that cause harm (disease) in humans. They include bacteria, viruses, fungi, protozoa, and prions.

Bacteria

Bacteria are prokaryotic (lack a true nucleus), unicellular organisms that usually multiply by cell division. Some bacteria are capable of producing spores, which are a resistant form of the bacteria that can tolerate adverse conditions such as extreme heat, cold, humidity, etc. Bacteria compose the largest group of pathogens. Antibiotics are effective against bacteria. Table 1 identifies some of the basic characteristics of bacteria in general.



Algae and bacteria in a Scanning Electron Microscope, magnification 5000x

Bacteria are classified according to their shape. Bacilli are straight, slender, rod-shaped bacterial cells that may have tapered ends. Examples of diseases caused by bacilli include tetanus (*clostridium tetani*), tuberculosis (*mycobacterium tuberculosis*), and typhoid (*salmonella typhi*). Vibrio, such as cholera (*vibrio cholera*), are comma-shaped rods. Spirilla, such as *spirillum volutrans,* which is a cause of dysentery, are corkscrew-shaped rods. Spirochetes, such as *treponema pallidum,* which causes syphilis, are corkscrew-shaped rods that are capable of waving and twisting motions.

Cocci are spherical or round cells that appear in characteristic arrangements. Diplococci, such as gonorrhea (*neisseria gonorrhoeae*) and bacterial meningitis (*neisseria meningitides*) appear in pairs. Streptococci, such as strep throat (*Streptococcus pyogenes*), appear in chains. Staphylococci such as staph (staphylococcus aureus) appear in clusters.

Bacteria are also classified by the way they react to the gram-staining procedure, when the organism is affixed to a slide and stained with blue/purple dye; a weak iodine solution is then added to promote colorfastness, and the slide is washed with alcohol. If the blue/purple dye remains, the organism is called gram positive. If the blue/purple dye is removed, the organism is called gram negative; the gram negative bacteria is then stained with pink/red dye to enhance visibility.

Viruses

Viruses are small microorganisms (smaller than bacteria) that cannot replicate unless they are within a living cell (obligate intracellular parasites). Most viruses are pathogenic with the exception of bacteriocidal viruses called bacteriophages. All viruses are capable of mutation. Viruses

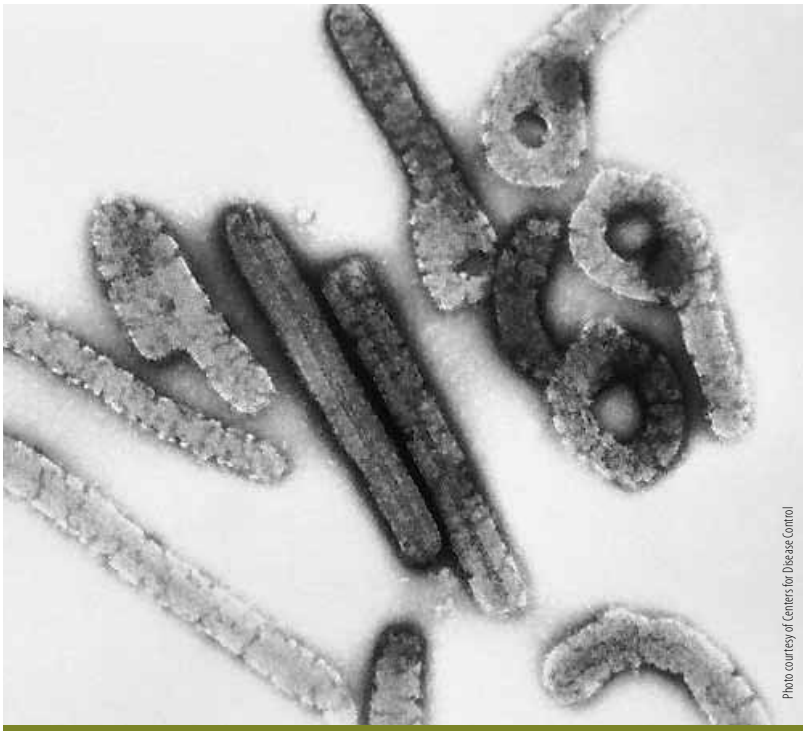


Photo courtesy of Centers for Disease Control

Marburg virus magnified 100,000x

are not affected by antibiotics. Examples of viral pathogens include rhinovirus (common cold), hepatitis viruses A-G, rubella (German measles), rubeolla (measles), varicella (chicken pox), human immunodeficiency virus (the cause of acquired immune deficiency syndrome – AIDS), etc.

Fungi

Fungi are eukaryotic (contain a true nucleus), unicellular or filamentous (threadlike in structure) organisms that multiply by budding (sexual) or spore formation (asexual). Some fungi resemble plants; however, fungi lack roots, stems, leaves, and chlorophyll and grow in irregular masses. Yeasts, molds and mushrooms are all considered fungi. They require an external carbon source and are chemoheterotrophic (use chemicals as their energy source). Fungi may be saprophytic or parasitic. Antimycotic (antifungal) drugs are effective against fungi. Fungi are typically opportunistic in humans and are likely to occur in individuals, who experience immune deficiency, immunosuppression, corticosteroid use, chemotherapy, antibiotic therapy, or suffer from a comorbid condition, such as diabetes. Pathogens that cause mycoses include aspergillosis (mold that commonly affects the respiratory tract and sinuses), candida albicans (yeast that is normal human mucosal flora that can easily become an opportunistic infection when the patient is undergoing chemotherapy or is on antibiotic therapy), and cryptococcus neoformans (yeast that causes a form of meningitis).

Protozoa

Protozoa are unicellular, animal-like microorganisms that are saprophytes. Amoeba are a type of protozoa. Protozoan infections are spread by fecal-oral contamination, ingestion of contaminated food or water, and vectors such as mosquitoes. Examples of protozoan infections include gastroenteritis (*entamoeba histolytica, giardia lamblia*), malaria (*plasmodium maleriae*), and vaginitis (*trichomonas vaginalis*).

Prions

Prions (pronounced "pree-ons") were first identified in 1982, by Stanley Prusiner of the University of California, San Francisco. Prions are simple proteins that are much smaller than a virus and are unique, because they lack a genome (all other known infectious agents contain genetic material). The word prion represents the term proteinaceous infectious particle. Protein particles exist in two forms. The normal, an innocuous (harmless) protein called PrPc can change its shape to a harmful, disease-causing form called PrPSc. The abnormal, conversion from PrPc to PrPSc then proceeds via a chain reaction. Several PrPSc proteins form long, filamentous aggregates that gradually damage neuronal tissue. All known prion diseases affect the nervous system and are fatal because the immune system does not recognize proteins as foreign and protection does not develop. Theories concerning transmission of prion diseases include genetic transmission, spontaneous mutation of the proteinaceous particle, consumption of infected meat (including cannibalism), transplantation/injection of contaminated tissue, such as dura mater grafts, corneal transplants, and injection of human growth hormone, and contact with contaminated surgical instruments. Prion diseases affect animals (scrapie affects sheep, bovine spongiform encephalopathy or mad cow disease affects cattle, chronic wasting disease affects deer) and humans (Kuru, which has now been eradicated, and Creutzfeldt-Jacob Disease – CJD).

INFECTIOUS PROCESS

Infections that are contagious are called communicable. Communicable diseases are classified in three ways.

- Epidemic – affects many people in the same region at the same time.
- Endemic – continuously affects some people in a particular region.
- Pandemic – prevalent throughout an entire country, continent or the world.

Infections are also classified according to how they are acquired. A nosocomial infection occurs as a result of receiving health care. For example, a surgical site infection would be considered nosocomial. A community-acquired infection, such as the common cold, occurs as a result of being part of society.

A diagnosis is a conclusion related to the nature of the disease. Diagnosis is reached by identifying symptoms (conditions noted subjectively by the patient), signs (conditions noted objectively by the health care provider), and tests, such as laboratory studies and diagnostic imaging that provide factual information concerning the patient. The term prognosis represents a prediction of the probable outcome of the disease (based on the condition of the patient and the expected course of the disease).

Sources of infectious disease (contamination) are the environment (fomites, air and vectors including humans who harbor pathogens in their hair, skin, subungual areas, blood and other body fluids).

Modes or routes of transmission of pathogens include air currents, direct and indirect contact, common vehicle (infection carried in the blood), and vectors.

The infectious process involves several conditions. Every exposure to a pathogen may not result in infection. First, the individual must be exposed to a pathogen, and the pathogen must be able to gain entry to the body. Portals of entry include the skin (intact or traumatized), respiratory tract, digestive tract, urinary tract, and the reproductive system. The dose (number of organisms that invade the body) must be sufficient to produce an infection, and the organism must have the power (virulence) to overcome the defenses of the host and the ability to produce toxins.

Certain individuals may be predisposed to infection because of age, gender, heredity, life situations/habits, occupation, exposure to the elements, preexisting comorbid conditions, and/or psychogenic influences.

IMMUNITY

The human body has several defenses against disease. They are nonspecific and specific immune responses.

Nonspecific Defenses

Nonspecific defenses against disease are effective in reducing the risk of infection from all pathogens. Examples of nonspecific defenses include:

- Skin – Acts as a mechanical barrier (often referred to as the "first line of defense").
- Mucous Membranes – Also act as a mechanical barrier, secretions trap foreign material, cilia move impurities out of the body.
- Body Secretions – Such as tears, sweat, saliva, digestive juices wash away organisms and contain acids, enzymes, or chemicals to destroy invaders.
- Reflexes – Such as coughing and sneezing remove foreign matter.
- Vomiting and Diarrhea – Expel organisms and toxins.
- Phagocytosis – White blood cells, primarily neutrophils and macrophages, take in and destroy waste and foreign material.
- Natural Killer Cells – Type of lymphocyte that recognizes abnormal cells and destroys them.
- Inflammation – The body's protective response to pathogens. The classic local signs of inflammation are pain (dolor), heat (calor), redness (rubor), and swelling (tumor). The classic systemic sign of inflammation is fever.
- Interferon – Proteins produced by lymphocytes that "interfere" with the infectious process by triggering an immune response.

SPECIFIC DEFENSES

Specific defenses are the power of an individual to resist or overcome the effects of a specific pathogen (often referred to as the "final line of defense"). There are several types of specific immunity.

Certain individuals may be predisposed to infection because of age, gender, heredity, life situations/habits, occupation, exposure to the elements, preexisting comorbid conditions, and/or psychogenic influence.

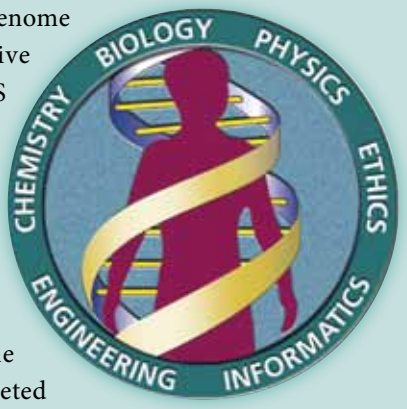
- Inborn Immunity – An individual is born with certain defenses because of their species (Humans don't "usually" get animal diseases, such as distemper, and animals don't get measles); their race (Some racial groups appear to be more immune to certain diseases, such as polio), or their individuality (inherited immunity).
- Acquired Immunity – Certain defenses develop during an individual's lifetime. Acquired immunity may be naturally acquired or artificially acquired.
- Naturally Acquired Immunity – Results from contraction and survival of a specific disease, because the body produces antibodies against the invading agent. Natural immunity may be active or passive.
- Active – The host is directly involved in production of antibodies (usually effective for an extended period of time, possibly lifetime).
- Passive – Antibodies are passed from mother to fetus through the placenta or breast milk (may be effective for up to six months).
- Artificially Acquired Immunity – Results from purposeful exposure to an attenuated (weakened) or biotechnologically engineered (recombinant DNA technology) agent. Artificially acquired immunity may be active or passive.
- Immunization (active) – Vaccination stimulates antibody production.
- Immunization (passive) – Antiserum contains antibodies from other sources. Examples include gamma globulin (given to individuals exposed to HAV, measles, etc. who have not been immunized) RhoGAM (human), antivenin (snakebite sera), and rabies antiserum (to treat victims of bites of rabid animals).

There are a number of public health considerations that are also important in reducing the spread of pathogens. They include:

- Disposal of sewage and garbage
- Water purification
- Prevention of food contamination
- Pasteurization

In the health care setting, policies and procedures are in place to reduce the risk of the spread of infection. Procedures include implementation of standard precautions such as frequent hand washing as well as disinfection and sterilization procedures.

HUMAN GENOME PROJECT (HGP)



In 1990, the US Human Genome Project was a collaborative effort launched by the US Department of Energy and the National Institutes of Health. The original timeframe was projected to span 15 years, but the advances in technology truncated the timeline, and it was completed in 2003. The project proposed lofty goals that included:

- Identification of the estimated 20,000 to 23,000 human DNA genes
- Determining the sequences of the three billion chemical base pairs composing human DNA
- Recording this information in databases
- Sharing related technologies with the private sector
- Discussing the related ethical, legal and social issues

Initially, the researchers studied the genetic composition of many other organisms, some nonhuman, including Escherichia coli, fruit fly and a laboratory mouse.

The importance of genomes

A genome is a term representing all DNA in an organism, including its genes. The genes incorporate all of the information for making all the required proteins. In turn, these proteins determine the appearance of the organism, how the body metabolizes food or combats infection and, in some cases, behavior.

Four chemicals, or bases, compose DNA. Adenine, cytosine, guanine and thymine (A, C, G and T) are repeated by the millions (possibly billions) throughout a genome. The human genome has three billion pairs of bases.

What is crucial is the particular order, or sequencing, of these bases. This order is responsible for the diversity of life. The sequencing determines whether an organism is human or plant, insect or animal. Each specie has its own genomes. Since all living organisms have some DNA similarities, knowledge obtained

from the research into nonhuman genomes, has the future possibility of benefiting human biology.

Understanding the effects of DNA variations among individuals will help science to develop new methods to diagnose, treat and possibly prevent disorders that affect humanity. It is also important for researchers to engage in nonhuman DNA scientific exploration, since understanding many of the characteristics in plants, animals and bacteria can contribute knowledge that may be applied to benefit human health, agriculture, environmental remediation and carbon sequestration.

Specific current and potential applications include

- Molecular medicine
- Energy sources and environmental applications
- Risk assessment
- Bioarcheology, anthropology, evolution and human migration
- DNA forensics
- Livestock breeding

The first printout of the human genome to be presented as a series of books, displayed in the "Medicine Now" room at the Wellcome Collection, London. The 3.4 billion units of DNA code are transcribed into more than a hundred volumes, each a thousand pages long, in type so small as to be barely legible.

The developing technology that resulted from the Human Genome Project is exerting a dramatic influence on biomedical research, and in the future holds the promise of revolutionizing the broad expanse of biological research and clinical medicine. Teams have been able to produce detailed genome maps that have aided medical researchers exploring genes associated with numerous genetic conditions, including myotonic dystrophy, fragile X syndrome, neurofibromatosis types 1 and 2, inherited colon cancer Alzheimer's disease and familial breast cancer.

What looks promising is a new direction for molecular medicine that places less emphasis on treating symptoms and instead stresses exploring the most fundamental causes of the disease. Rapid and more exact diagnostic tests will facilitate earlier treatment in hundreds of conditions. Gene therapy will enable researchers to develop new classes of drugs, immunotherapy techniques, avoidance of environmental conditions that may trigger disease and potentially augmentation or replacement of defective genes.

For energy and environmental applications, it is interesting to note that microbial enzymes have been used to bleach paper pulp, stone wash denim, remove lipstick from glassware, break down starch in brewing and coagulate milk protein for cheese production.

Learning more about human genomes will help individuals exposed to toxic agents since some people are more susceptible to such agents than others. Such knowledge about human variability will aid in predicting the effects of low-level radiation exposure and other substances, particularly in terms of cancer risk.

Knowledge of the human genome aids in the understanding of human evolution and the common biology shared by all life. Comparative genomics between humans and mice has led to similar genes associated with diseases and traits.

DNA forensics has already proven critical in the release of individuals who were wrongly convicted of crimes. It is also crucial in organ donor matching, identifying protected species and determining bacterial contamination in food.

Knowledge of plant and animal genomes will facilitate the development of stronger, more disease-resistant plants and animals. In one application using tobacco, a researcher produced a bacterial enzyme that breaks down explosives such as TNT and dinitroglycerin. These substances would normally require centuries to break down in the soil, and now plants can be grown in the polluted area to remediate the contamination.

Controversies concerning gene research exist and more dialog needs to take place. But the wide-ranging benefits are impressive and hold great promise for the future.

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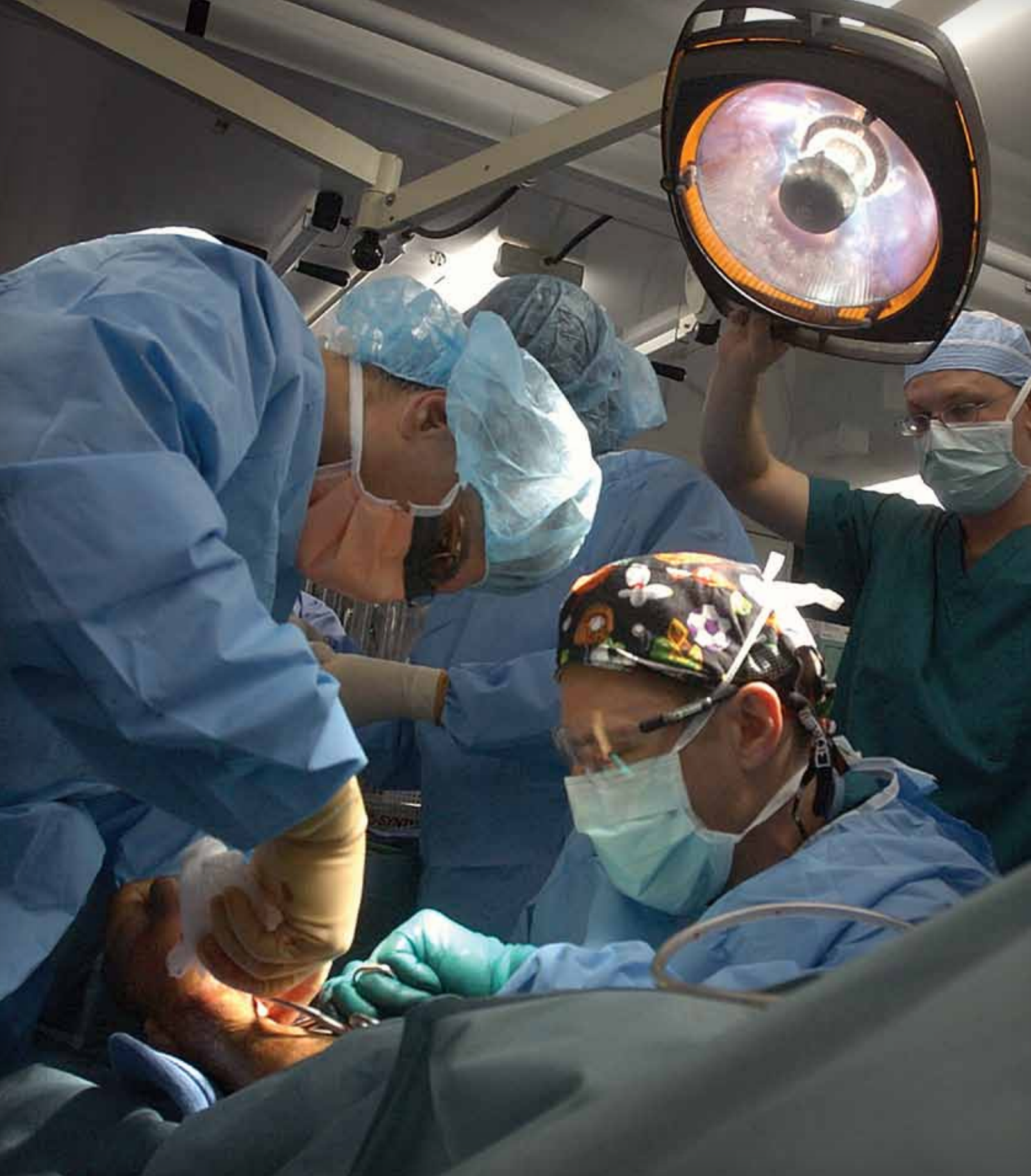


Transmission-Based Isolation Precautions in the OR:

CRITICAL PRACTICES TO PREVENT THE SPREAD OF INFECTIOUS DISEASES IN THE OPERATIVE SETTING

Julia Jackson, CST, MEd, FAST

This article will introduce surgical technologists to the CDC-recommended precautions to prevent transmission of infectious organisms in the health care setting and delineate the specific practices used in the perioperative setting.

INTRODUCTION

In order to prevent the spread of infectious organisms in the health care setting, one must understand how and where they live, how they are transmitted, and how to interrupt the transmission to patients and health care workers (HCW). This article discusses health care-associated infection (HAI), reviews terminology related to infection prevention, describes organisms responsible for these infections, and reviews best practices to prevent their spread using Standard Precautions and Transmission-Based Isolation Precautions in the OR setting.

A report from the CDC updates previous estimates of health care-associated infections. In American hospitals alone, health care-associated infections account for an estimated 1.7 million infections with annual direct medical costs to hospitals in the range of $28-45 billion, and result in 99,000 associated deaths each year. Catheters and invasive devices are the number one exogenous cause of hospital-associated infections.[1] Published studies estimate that up to 70 percent of HAIs may be preventable.[2] Approximately 290,000 surgical site infections (SSIs) are diagnosed each year and cost between $10,000-25,000 to treat.[3]

LEARNING OBJECTIVES

- Define health care associated infection (HAI)
- List the common infectious organisms found in the health care setting
- Differentiate colonization from infection
- Explain the role of Personal Protective Equipment (PPE)
- Compare and Contrast Standard Precautions (SP) from Transmission Based Precautions (TBP)

SSI is the second most common type of HAI, accounting for 22 percent of all HAIs. Incision is the most common single site of nosocomial infection in surgical patients, accounting for 30-40 percent of all infections in such patients. Each SSI is associated with approximately a week to 10 additional postoperative hospital days.[4,5] Patients who contract an SSI have a risk of death that is between two and 11 times greater than operative patients without an SSI.[6,7] Seventy-seven percent of deaths among patients with an SSI are directly attributable to the SSI.[8]

PREVENTING THE TRANSMISSION OF INFECTIOUS DISEASES

The "chain of infection" is a model that shows each of the conditions for the spread of infectious microorganisms (Figure 1). "All infectious diseases are caused by a microorganism (*eg*, bacteria, virus, mold, fungi, or parasite). For survival, each microorganism sustains itself in a source. The source may be a nonliving host, such as a human or animal, or a nonliving source, such as biohazardous waste or laboratory specimen. To cause a disease, the microorganism must have a portal of exit from the source (*eg*, respiratory tract or spill) and a method of spread."[9] Methods of spread for infectious diseases are airborne, droplet, contact (direct and indirect), bloodborne, vector (insect), and fecal-oral. The microorganism must find its way into a new host via a port of entry. Ports of entry include breaks in skin (cuts, scrapes and needlesticks), exposure of mucous membranes, respiratory tract or oral ingestion. Lastly, the host must be susceptible to the disease. Susceptibility includes current illness, lack of vaccination, immunocompromised state, open incisions or direct transmission during an invasive procedure. To prevent the spread of infection, we must continually break the chain of infection.

FIGURE 1. BREAKING THE CHAIN OF INFECTION

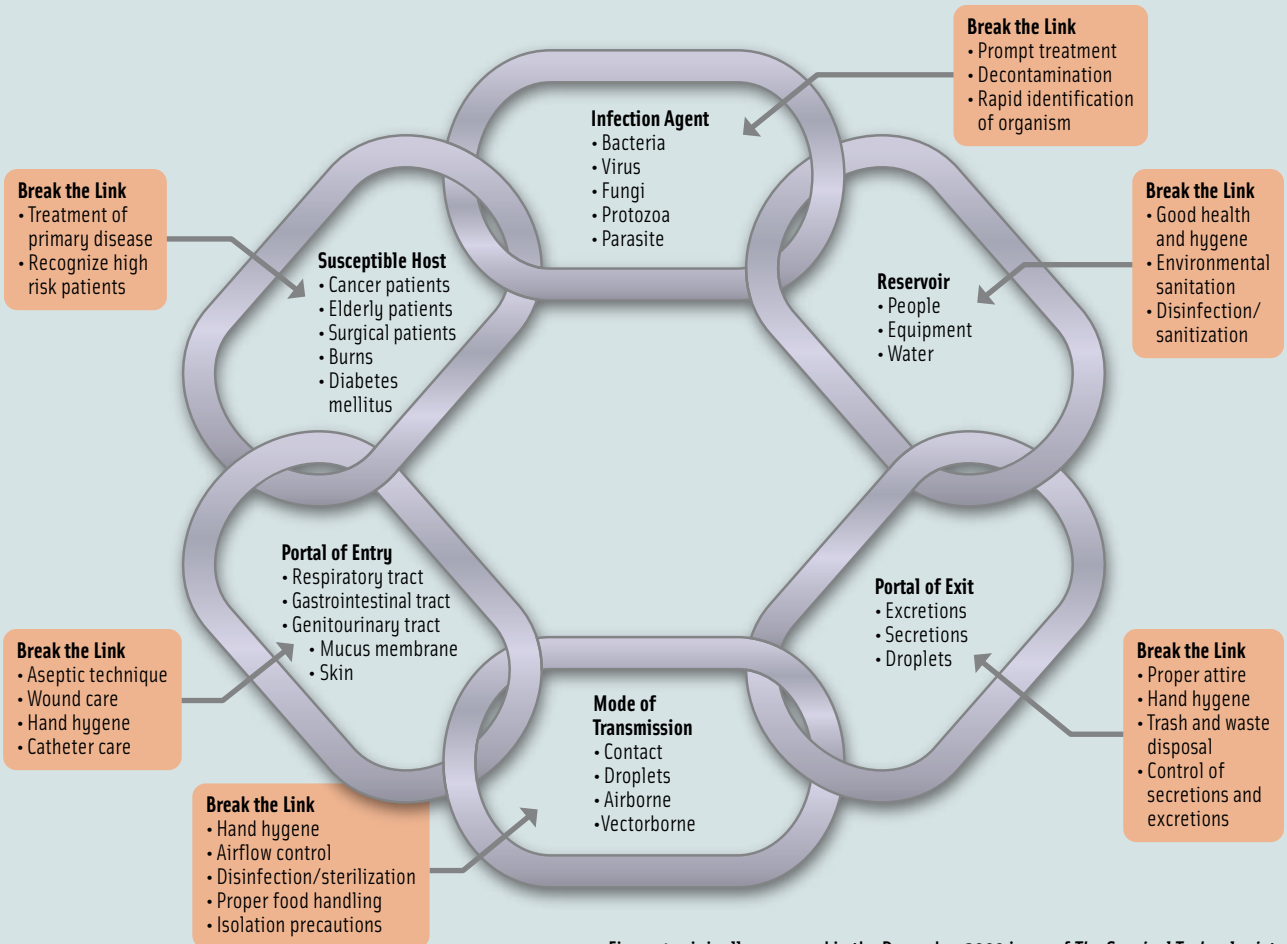


Figure 1 originally appeared in the December 2009 issue of *The Surgical Technologist*

PART I: TERMINOLOGY REVIEW

Agents of Infection

Airborne infectious agents are carried on the air currents for periods of time in sub-micron-sized respiratory droplets. Airborne precautions prevent transmission of infectious agents that remain infectious over long distances when suspended in the air (*eg,* rubeola virus [measles], varicella virus [chickenpox and disseminated zoster/shingles], and *Mycobacterium tuberculosis*). Health care personnel caring for patients on airborne precautions must wear a mask or respirator that is donned prior to entering the room. Whenever possible, nonimmune personnel should not care for patients with vaccine-preventable airborne diseases. Negative-pressure isolation rooms are used to prevent organisms from travelling on air currents outside the room.

Bioaerosols are an airborne dispersion of particles containing whole or parts of biological entities, such as bacteria, viruses, dust mites, fungal hyphae, or fungal spores. Infectious bioaerosols can be generated from human sources (*eg,* coughing, sneezing, talking or singing; during suctioning or wound irrigation), wet environmental sources (*eg*, HVAC and cooling tower water with Legionella) or dry sources (*eg,* construction dust with spores produced by *Aspergillus* spp.).

Blood-borne pathogens (BBP) are pathogenic microorganisms that are carried or transmitted via the blood and fluids that contain blood. This includes HBV, HCV, and HIV.

Colonization describes the presence of microorganisms on or within body sites without infection or immune response, and is a source of potential transmission. In many instances, colonization and carriage are synonymous. Multi-drug-resistant organism (MDRO)-colonized patients are isolated in many institutions to prevent the spread to other patients via HCW hands, clothing and equipment.

Extended spectrum beta-lactamase [ESBL]-producing organisms are usually gram-negative rods, such as *Pseudomonas aeruginosa*, *E. coli* and *Klebsiella* pneumonia. They produce an enzyme that deactivates most beta-lactam antibiotics, including penicillin, cephalosporin and aztreonam.[10] Infections with ESBL-producing organisms have been associated with poor outcomes. Most facilities isolate patients infected or colonized with ESBL-producing gram negative rods.

Multidrug-resistant organisms (MDROs) generally refer to bacteria that are resistant to one or more classes of antimicrobial agents and usually are resistant to all but one or two commercially-available antimicrobial agents (*eg,* Methicillin-resistant *Staphylococcus aureus* (MRSA), Vancomycin-resistant *Enterococcus* (VRE), drug resistant Acinetobacter, or extended-spectrum beta-lactamase [ESBL]-producing or intrinsically resistant gram-negative bacilli such as drug resistant *E. coli*).

Types of Infection

A **health care-associated infection (HAI)** is an infection that develops in a patient who is cared for in any setting where health care is delivered and is directly related to receiving that care. In ambulatory and home settings, HAI applies to any infection that is associated with a medical or surgical intervention. Since the geographic location of infection acquisition is often uncertain, the preferred term is considered to be health care-*associated* rather than health care-*acquired*. Surgical site infections are HAIs.

Nosocomial infection is a term derived from two Greek words, "*nosos*" (disease) and "*komeion*" (to take care of), and refers to any infection that develops during, or as a result of, an admission to an acute-care facility and was not incubating at the time of admission.

An **opportunistic infection** is an infection by a microorganism that normally does not cause disease but becomes pathogenic when the body's immune system is impaired and unable to fight off infection. This occurs in persons with abnormally-functioning immune systems (AIDS patients or transplant patients receiving immunosuppressive drugs).

Precautions

Standard precautions[12] are a group of infection prevention practices that apply to all patients, regardless of diagnosis or presumed infection status. Standard precautions are based on the principle that all blood, body fluids, secretions, excretions (except sweat), nonintact skin, and mucous membranes may contain transmissible infectious agents. OSHA's 1991 rule on occupational exposure to bloodborne pathogens in health care settings mandates these precautions in all health care settings.

Principles:

Standard precautions include the use of personal protective equipment, hand hygiene, respiratory hygiene and safe sharps practices.

Practices:

Touching mucous membranes, nonintact skin and body substances require the use of PPE. In addition, equipment or items in the patient environment likely to have been con-

taminated with blood or body fluids must be handled in a manner to prevent transmission of infectious agents (*eg*, wear gloves for handling, contain heavily-soiled equipment, properly clean and disinfect or sterilize reusable equipment before use on another patient).

Transmission-based precautions are a group of infection-prevention practices used when the routes of transmission are not completely interrupted using standard precautions alone. These organisms are not transmitted through blood and body fluids alone. For some diseases that have multiple routes of transmission (*eg,* SARS), more than one transmission-based precaution category may be used. Consult the *HICPAC/CDC Isolation Guideline* recommended precautions for specific infections.

Principles:

Transmission-based precautions are always used in addition to standard precautions. They include the use of personal protective equipment, hand hygiene and patient isolation practices, and are used to help decrease the potential for HAI in the patient population and protect health care workers during patient care.

Practices:

Touching patients or their environment (regardless of visible soil) always requires the use of personal protective equipment (PPE) such as gowns, gloves and eye protection. In addition, equipment or items in the patient environment must be handled in a manner to prevent transmission of infectious agents (*eg*, wear gloves for handling, contain heavily-soiled equipment, properly clean and disinfect or sterilize reusable equipment before use on another patient).

There are three categories of transmission-based precautions: contact precautions, droplet precautions, and airborne precautions.

Airborne precautions include the use of **airborne isolation rooms (AIIR)**, also known as negative-pressure isolation rooms, which are single-occupancy patient-care rooms used to isolate persons with a suspected or confirmed airborne infectious disease. Air pressure in the room is set as negative to the outside of the room, which means that air flows into the room upon door opening (to keep potential microorganisms in the air inside the room). Environmental factors (higher air exchange rates) are controlled in AIIRs to minimize the transmission of infectious agents that are usually transmitted from person to person by droplet nuclei associated with coughing or aerosolization of contaminated fluids. Operating rooms are not AIIR/negative-pressure rooms. PACU usually has a negative pressure room in which to recover respiratory isolation patients. AIIR room doors must remain closed in order to maintain the pressure differential. If the door remains open, the pressure between the room and the hall will equalize, resulting in the movement of organisms from inside to outside of the room. Barrier precautions are an extension of contact precautions.

Barrier Precautions include masks, hats, gowns, gloves, eye protection and drapes, which create a protective barrier between health care workers and patients. Barrier precautions are an extension of contact precautions.

Contact Precautions are intended to prevent transmission of infectious agents, most commonly drug resistant organisms, which are spread by direct or indirect contact with the patient or the patient's environment. Contact precautions are used in addition to standard precautions. Health care personnel caring for patients in contact precautions should wear a gown and gloves for all interactions that may involve contact with the patient or potentially contaminated areas in the patient's environment (*eg*, stretcher, linens). Donning PPE before room entry and discarding it before exiting is necessary in order to contain pathogens in the room—especially those transmitted through environmental contamination (*eg*, VRE, C. *difficile*, MRSA, noroviruses/intestinal tract pathogens and RSV).

Droplet Precautions are intended to prevent transmission of pathogens spread through close-respiratory or mucous-membrane contact with respiratory secretions.

A small MRSA colony under an electron microscope. This colony is approximately two microns across.

Because these pathogens do not float on air currents, as with airborne infectious organisms, special air-handling and ventilation are not required to prevent droplet transmission. Infectious agents for which droplet precautions

are indicated include *B. pertussis*, influenza virus, H1N1, adenovirus, rhinovirus, *N. meningitides*, and systemic/invasive group *A. streptococcus* (for the first 24 hours of antimicrobial therapy). Health care personnel must wear a mask (a respirator is not necessary) for close contact (within three feet) with the infected patient. The mask is generally donned upon room entry. Patients on droplet precautions, who must be transported outside of the room, should wear a mask and follow respiratory hygiene/cough etiquette.

The residue of evaporated droplets, which can contain particles approximately three-five microns in size, is usually expelled in an area within three feet of the person, and is deposited in the environment. These infectious droplets remain on the patient, items and equipment (stretcher, bedside table, IV poles etc) and do not float on air currents.

Engineering controls require the removal or isolation of a workplace hazard through technology. AIIRs, a protective environment, safety needle devices and sharps containers are examples of engineering controls.

Hand hygiene is a general term that applies to any one of the following: 1) handwashing with plain (nonantimicrobial) soap and water; 2) antiseptic handwash (soap containing antiseptic agents and water); 3) antiseptic handrub (waterless antiseptic product, most often alcohol-based, rubbed on all surfaces of the hands); or 4) surgical hand antisepsis (antiseptic handwash or antiseptic handrub performed preoperative-

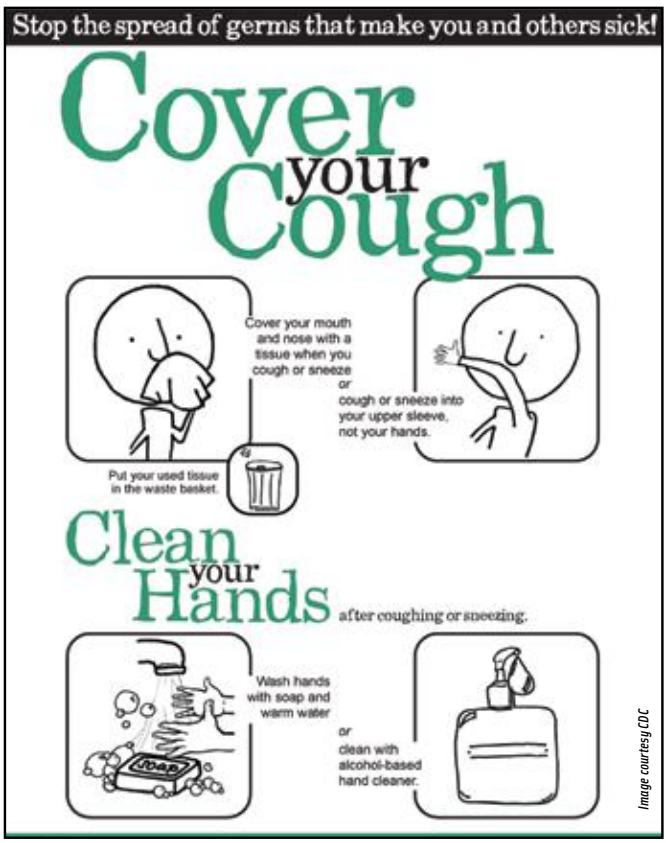
CDC Best Practices for Standard Precautions and Transmission-Based Precautions

COMPONENT	Standard Precautions (Every Patient)	Transmission Based Precautions (Isolation Patients) *May vary based on facility. *Know your facility's protocol!*
Hand hygiene	After touching blood, body fluids, secretions, excretions and contaminated items. Immediately after removing gloves and between patient contacts.	Same as SP
Gloves	For touching blood, body fluids, secretions, excretions and contaminated items. Use for touching mucous membranes and nonintact skin.	For *all contact* with a patient, patient's environment, and/or equipment in a patient's room. (Contact and droplet only.)
Gown	During procedures and patient-care activities when contact of clothing/exposed skin with blood/body fluids, secretions and excretions is anticipated.	For *all contact* with a patient, patient's environment, and/or equipment in a patient's room. (Contact and droplet only.)
Mask, eye protection (goggles), face shield	During procedures and patient-care activities likely to generate splashes or sprays of blood, body fluids and secretions. Especially during suctioning and endotracheal intubation.	Droplet: Mask with eye protection must be worn within three feet of the patient. Airborne: Respirator (N-95/PAPR) or surgical mask before entering a room. TB always requires a fit-tested respirator. Refer to your facility's requirement for other organisms such as varicella/disseminated zoster.
Patient-care equipment	Handle in a manner that prevents transfer of microorganisms to others and to the environment. Wear gloves if visibly contaminated and perform hand hygiene.	*All contact* with all equipment used on a patient or in a patient's room requires gown and gloves. *All* equipment must be disinfected before leaving the room. (Contact and droplet only.)
Environmental control	Develop procedures for routine care, cleaning, and disinfection of environmental surfaces – especially frequently-touched surfaces in patient-care areas. Standard cleaning with low-level disinfectants for noncritical items such as tables, Mayo, BP cuffs etc.	Organism-specific protocols are required (*eg,* TB, *Clostridium difficile*) for cleaning. TB requires an intermediate-level disinfectant. *Clostridium difficile* requires bleach.
Textiles and laundry	Handle in a manner that prevents the transfer of microorganisms to others and to the environment.	*All contact* with laundry/linen that contacted patient or was in a patient's room requires gown and gloves. (Contact and droplet only.)
Needles and other sharps	Do not recap, bend, break or hand-manipulate used needles. If recapping is required, use a one-handed scoop technique only. Use safety features when available and place used sharps in a puncture-resistant container.	Same as SP
Patient resuscitation	Use a mouthpiece, resuscitation bag or other ventilation devices to prevent contact.	Based on the situation, if time permits, wear gown and gloves. (Contact and droplet only.)

ly by surgical personnel to eliminate transient hand flora and reduce resident hand flora). Hand hygiene is a critical method of preventing infection. Health care workers not cleansing their hands before and after patient/environment contact is the most common mode of transmitting microorganisms to patients.

A **protective environment** is a specialized patient-care area, usually in a hospital, that has a positive air flow relative to the corridor (*ie*, air flows from the room to the outside adjacent space). Other components include the use of scrubbable surfaces instead of materials such as upholstery or carpeting, cleaning to prevent dust accumulation, and prohibition of fresh flowers or potted plants. The operating room is a protective environment.

Respiratory hygiene, and **cough etiquette** are a combination of measures designed to minimize the transmission of respiratory pathogens via droplet or airborne routes in the health care setting. The components of respiratory hygiene/cough etiquette are: 1) covering the mouth and nose during coughing and sneezing; 2) using tissues to contain respiratory secretions with prompt disposal into a no-touch receptacle; 3) offering a surgical mask to persons who are coughing to decrease contamination of the surrounding environment; and 4) turning the head away from others and maintaining spatial separation, ideally more than three feet, when coughing. These measures are targeted to all patients with symptoms of respiratory infection and their accompanying family members or friends beginning at the point of initial encounter with a health care setting.



Source control is the process of containing an infectious agent either at the portal of exit from the body or within a confined space. The term is applied most frequently to containment of infectious agents transmitted by the respiratory route but could apply to other routes of transmission, (*eg*, a draining wound, vesicular or bullous skin lesions). Respiratory hygiene/cough etiquette that encourages individuals to "cover your cough" and wear a mask is a source control measure.

Protective Equipment

A **high-efficiency particulate air (HEPA) filter** is an air filter that removes more than 99.97 percent of particles over 0.3 microns in size (the most penetrating particle size) at a specified flow rate of air.

A micron (μm) is a unit of measure equivalent to one-millionth of a meter. They are also called micrometers and are equal to 0.001 mm.

Personal protective equipment (PPE) is made up of a variety of barriers used alone or in combination to protect mucous membranes, skin and clothing from contact with infectious agents. PPE includes gloves, masks, respirators, goggles, face shields and gowns.

A **procedure mask** covers the nose and mouth and is intended for use in general patient care situations. These masks generally attach to the face with ear loops rather than ties or elastic.

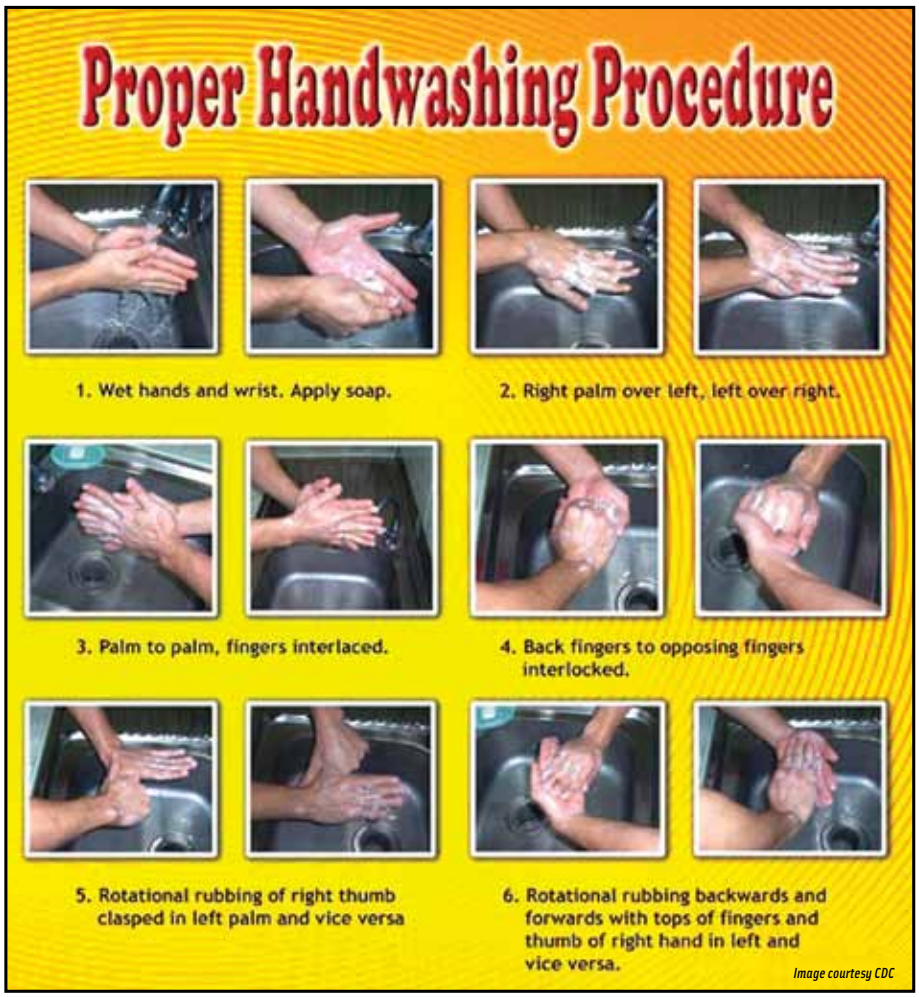
A **respirator** is a personal protective device worn by health care personnel to protect them from inhalation exposure to airborne infectious agents that are less than five microns in size. These include infectious droplet nuclei from patients with *M. tuberculosis,* smallpox, SARS-CoV. The CDC's National Institute for Occupational Safety and Health (NIOSH) certifies respirators used in health care settings. The N95 disposable particulate air purifying respirator and powered air-purifying respirators (PAPRS) with high efficiency filters are the types used most commonly by health care personnel.

Surgical masks are worn over the mouth and nose by operating room personnel during surgical procedures to protect both surgical patients and operating room personnel from transfer of microorganisms and body fluids. Surgical masks also are used to protect health care personnel from contact with large infectious droplets (larger than three

microns in size). Surgical masks do not protect against inhalation of small particles or droplet nuclei and should not be confused with particulate respirators that are recommended for protection against selected airborne infectious agents.

PART II: COMMON INFECTIOUS ORGANISMS FOUND IN THE HEALTH CARE SETTING

Infectious organisms are transmitted in the health care setting by various modes, such as direct or indirect contact, respiratory secretions and droplets, and through ingestion. One of the most common methods of transmission is through touching surfaces contaminated with bacteria, fungi or viruses and touching either one's self or the patient. Most HAIs are caused by HCWs transferring infectious organisms to patients, due to poor hand hygiene and sloppy practices, and not from patient to patient directly.



Bacteria, Fungi, Parasites and Viruses

Bacteria are single-celled organisms and multiply using cellular division and chromosomal replication. "A group of bacteria is referred to as a colony (you may see the number of bacteria present in a lab specimen result quantified as colony-forming units or CFU). The bacterial cell contains several components: DNA, ribosomes, membrane, and cell wall. Some bacteria may have additional components such as an outer membrane, capsule, flagella, pili, and endospores."[11] These components contribute to the microbe's ability to live, both in the body and in the environment. Bacteria are classified based on their morphological and chemical properties, which is called taxonomy.

Taxonomy of bacteria is based on the "Gram-stain characteristic (gram-positive v. gram-negative), the morphological features (cocci v. bacilli (rods)), and oxygen utilization (aerobic v. anaerobic)." There are other properties used to classify bacteria using laboratory techniques such as coagulase, hemolysis, and enzyme production. Bacteria are named according to genus and species and there are many species under a single genus. For example, *Staphylococcus* is a genus, but there are numerous species of *Staphylococcus.* The two most common species of *Staphylococcus* are: 1) *aureus* (both MRSA and MSSA); and 2) *epidermis* (AKA coagulase negative *Staphylococcus* or CNS).

Fungi tend to infect patients with altered immune systems and are classified into two groups based on their appearance: yeasts and molds. Yeasts are round and reproduce through budding. Molds have tube-like projections called hyphae and reproduce by elongation and fragmentation. Fungi produce spores and are not killed by antibiotics. The more common fungi found in surgical settings are *Aspergillus* (mold that lives in dust and can be spread during construction in the operating room), and *Candida* (yeast that lives in the gastrointestinal tract and can be found on skin).

Parasites are organisms that live in or on another and take advantage of the host. These organisms are classified into three categories: protozoa, flukes/tapeworms, and roundworms. *Pneumocystis carinii* is a protozoan that causes

pneumonia in immunocompromised patients, such AIDS patients; *P. carinii* is also classified as a fungus. *Trichomonas* is a protozoan that causes sexually transmitted diseases.

Viruses don't cause surgical-site infections, but are important to control in health care environments. Viruses need living host cells to grow and reproduce and are not killed by antibiotics. They have RNA or DNA, a protein coat, and sometimes an outer envelope (nonenveloped viruses are harder to kill in the environment). A virus can also lie dormant for years before it begins reproducing. Taxonomy is related to the size, RNA/DNA, the envelope, and the mode of replication. We use vaccines to prevent infection. Live vaccines are called "attenuated" and are weakened to the point that they can trigger our body to produce antibodies but not cause infection. Inactivated vaccines are heated or chemically treated and also trigger our body to produce antibodies without causing infection. Health care workers should be vaccinated against measles, mumps, varicella, influenza and hepatitis before working in a health care environment.

Prions are proteinaceous, infectious particles and have no DNA or RNA. Creutzfeldt-Jakob disease (CJD) is the most common prion we encounter in the operating room. CJD causes spongiform encephalopathy and profoundly affects the neurological system (rapid progression leads to death). CJD is spread through contact with infected tissue and is not killed using standard sterilization methods. It is important to remember that CJD requires special care and handling of instrumentation after use on these patients. Your operating room should have CJD precautions and protocols to follow in the event a CJD patient requires surgery.

Common Multidrug Resistant Organisms (MDROs) in the Health Care Setting

MRSA is a type of staph that is resistant to some of the antibiotics normally used to treat them. Approximately one percent of the general population is colonized with MRSA. One of the most common sites of MRSA colonization is the nose. Colonization may last for a short time or last for years. Infection occurs when the *staphylococcus* bacteria cause disease in the person. MRSA is most often spread by direct (hand) contact with the infected person. Vancomycin-resistant *enterococci* (VRE) is a germ that is typically only carried by some sick people. Therefore, VRE is often found in hospitals and other health care settings. People get VRE by direct contact (touching) with objects or surfaces that are contaminated with VRE. VRE is *not* spread through the air. People at risk for getting VRE are those who:

- have chronic illnesses
- have had recent surgery
- have weakened immune systems
- have recently taken certain antibiotics

In these people, contact with VRE may lead to colonization. People who are colonized with VRE may go on to develop an infection with VRE. The most common infections caused by VRE are urinary tract infections, wound infections and bloodstream infections. The people who are healthy may come in contact with VRE but are at a very low risk of becoming colonized or infected with VRE.

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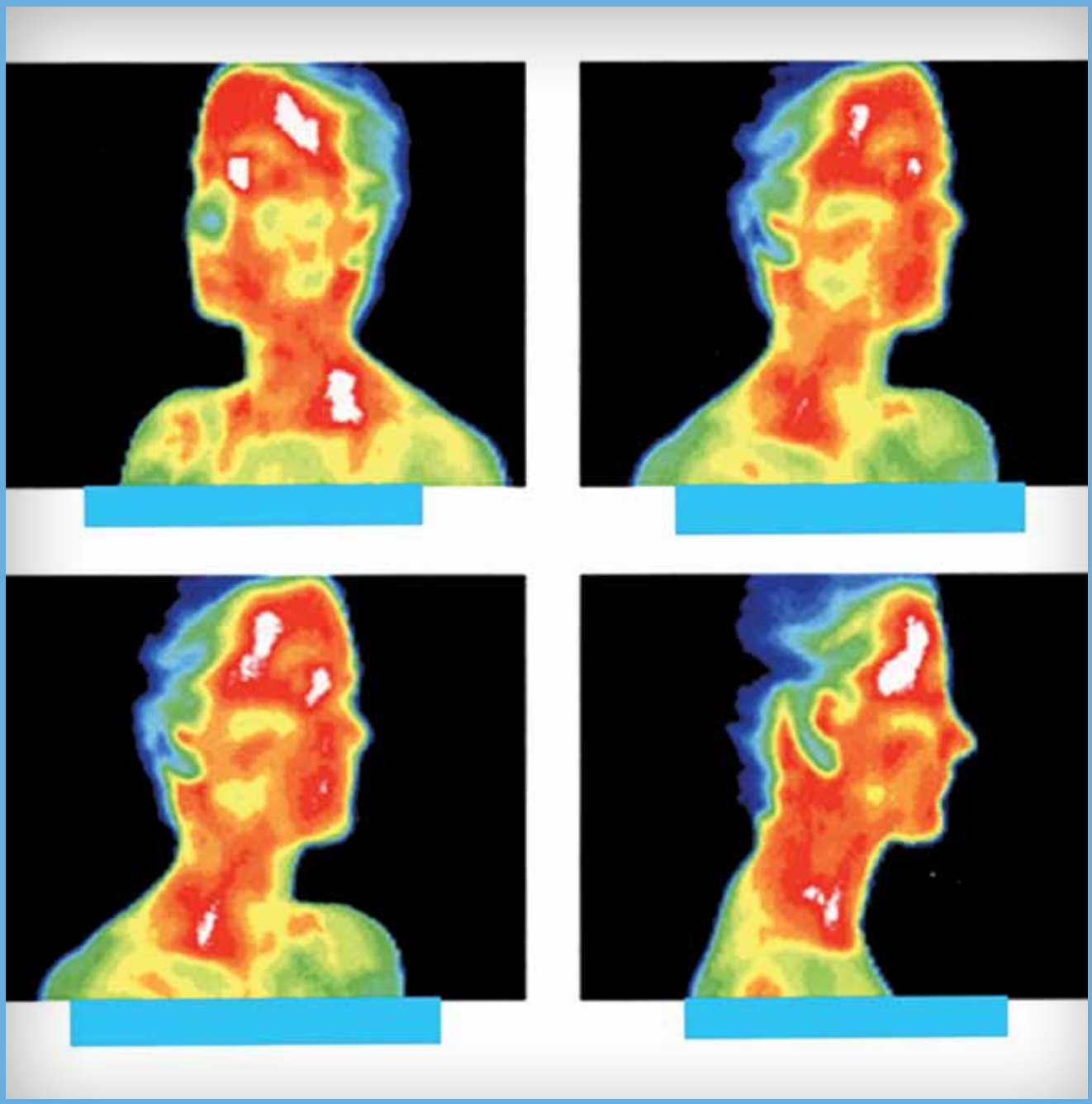


Malignant Hyperthermia Crisis

by Connie Corrigan CST, RN, CNOR, MS

FACTS ABOUT MALIGNANT HYPERTHERMIA

- Malignant hyperthermia (MH) is a rare complication of general surgery involving either halogenated, volatile anesthetic gases or depolarizing muscle relaxants as a triggering mechanism. This disease process has common symptoms including calcium build-up in the musculature, tachycardia, respiratory and metabolic acidosis, followed by hemodynamic failure.
- Currently only one medication, dantrolene sodium, is available for treatment of MH crisis. In addition to drug therapy, supportive measures taken by the entire perioperative team will help provide a positive outcome to a crisis situation.
- A MH crisis can be averted or the severity may be reduced if it is known that a patient has a susceptibility to the disease (through testing, family history, or previous crisis). Guidelines for preoperative evaluation of patients will be discussed.

MALIGNANT HYPERTHERMIA CRISIS

Malignant hyperthermia (MH) is a rare complication of general anesthesia involving a reaction to either volatile anesthetic gases (halothane, desflurane or isoflurane) or intravenous depolarizing muscle relaxants (succinylcholine).[1] This article will describe the perioperative team's role in identifying patients at risk for developing MH, the common signs and symptoms of a crisis situation, and treatment during a crisis as well as postoperative care.

LEARNING OBJECTIVES

- Review the necessary steps for a preoperative assessment for potential MH susceptibility
- Examine the causes of MH
- Assess the needs of your OR and its preparedness for a MH incident
- Evaluate the methods and materials necessary to successfully control a MH incident
- Identify the symptoms that indicate a MH incident

MALIGNANT HYPERTHERMIA PATHOPHYSIOLOGY

Skeletal muscle is composed of small myofibrils surrounded by transverse tubules (T-tubules) forming an intricate network between and through all the muscle fiber layers, allowing extracellular fluid to bathe the fibers.[2] In a normal muscular contraction, a calcium pump in the sarcoplasm will pump the calcium back into the tubules.[2] In MH, this pump fails, causing sustained muscle contraction.[3] The increase in calcium levels causes myocin filaments to activate, leading to stiff, rigid muscles.[4]

As calcium is pumped back and forth from the sarcoplasm to the T-tubules, adenosine triphosphate (ATP) is used, which releases energy and produces heat (basal metabolic energy).[5] A typical muscle cell only holds four-six seconds of ATP, and then becomes exhausted.[6] In MH, when susceptible individuals are exposed to triggering agents, and the calcium pumps fail, the increased amount of calcium in the myofibrils causes sustained muscle rigidity, an increase in carbon dioxide production, hypoxia, and rhabdomyolysis. The patient's metabolic rate begins to rise with the sustained muscular contractions, leading to tachycardia, a high demand for oxygen, and eventually, a rise in temperature.4 The lactic acid and the increase in carbon dioxide will soon lead to a metabolic acidosis.[7] As triglycerides are broken down for energy, free fatty acids alter the sodium channels, leading to hyponatremia.[8] Rhabdomyolysis is the breakdown of muscle fibers resulting in the release of myoglobin into the bloodstream, which can cause kidney damage.[15]

PREOPERATIVE ASSESSMENT

While it is a rare disease, proper screening of all surgical patients will identify a predisposition toward MH. Because of the familial tendency of this disease, staff should question patients scheduled for general anesthesia regarding family members who became sick or died either during surgery or as a result of anesthesia. Even if the answer is "No," more specific questioning is warranted to identify anyone having an elevated temperature, or a difficult or extended recovery from anesthetics.[3] It is important to note that some individuals will have the gene, but will fail to display symptoms until his or her second or third surgical procedure.[9]

Genetic testing can only identify 25-30 percent of MH-susceptible patients, due to more than 60 different mutations of the ryanodine receptor isoform 1 (RyR1), which is one of the genes controlling the calcium pumps in muscle cells.[10] The RyR1 gene is very large and testing all the possible mutation sites is expensive, so current procedures often involve only 17 of the most common mutations. The gold-standard for testing MH susceptibility is a muscle biopsy subjected to an *in vitro* caffeine-halothane-contracture test.[4] Currently, only eight institutions in North America offer the biopsy procedure due to the need to have fresh muscle to perform the test, which must be completed within five hours of retrieval.[11] This presents difficulty for patients because of the need for many to travel great distances, and pay for a relatively expensive procedure – conservative estimates project at least $6,000.[11]

MH is most commonly found in patients between two- and 42-years old, and most commonly in men.[1] Chang and Scher believe incidence of MH to be one in 15,000 children and one in 50,000 adults.[12] Hommertzheim and Steinke, as well as McNeil, note that although the disease affects all racial groups equally, there is prevalence in individuals who also have other neuromuscular disorders, such as Duchenne muscular dystrophy or osteogenesis imperfecta.[1,6] True incidence will vary depending on the concentration of affected families in a particular area. The Malignant Hyperthermia Association of the United States (MHAUS)[11] identifies several states with high incidence, including Wisconsin, Nebraska, West Virginia and Michigan.

Because of the familial tendency of this disease, staff should question patients scheduled for general anesthesia regarding family members who became sick or died either during surgery or as a result of anesthesia.

MANAGEMENT OF INTRAOPERATIVE CRISES

When it is known or suspected that a patient is susceptible to MH, any potential triggering agents, including succinylcholine and halogenated inhalation anesthetics, are eliminated from the anesthetic regimen.[3] Preoperative equipment and supplies should include a decontaminated anesthesia machine (as previous use of halogenated agents may linger in the unit), fresh soda-lime, a supply of dantrolene sodium on stand-by, and appropriate patient monitors (especially temperature and end-tidal carbon dioxide).[12]

However, if there is no suspicion of MH, and any of the triggering agents are used, attention to signs of MH crisis is important in order to start treatment immediately. All

Table 1. Dantrolene Mixing Time by Dose and Diluent Temperature

Dantrolene Dose	2.5 mg /kg		10 mg /kg	
72-kg Adult	A Diluent	W Diluent	A Diluent	W Diluent
*Time / seconds	94 seconds	59 seconds	94 seconds	59 seconds
Number of Vials	9 vials	9 vials	36 vials	36 vials
1 Mixer / minutes	14 minutes	9 minutes	56 minutes	35 minutes
3 Mixers / minutes	5 minutes	3 minutes	19 minutes	12 minutes

A = Ambient (22° C), W = Warmed Diluent Temperature (41° C)
*Comparative Study Results, Mean Times

Courtesy Anesthesia Patient Safety Foundation

health care workers caring for patients undergoing general anesthesia should understand the disease because the manifestations can occur rapidly. However, as Chang and Scher state, the onset of symptoms can take several minutes to several hours, and some reports indicate that the crisis began during the recovery phase in the post-anesthesia care unit (PACU).[12] Hommertzheim and Steinke state that the crisis may begin up to 12 hours after the end of the surgery.[1]

Masseter muscle rigidity, a jaw that is rigid longer than 90 seconds and is impossible to intubate or pass a laryngoscope through, can be one of the earliest signs of MH.[12] Other signs and symptoms that would indicate MH crisis include increased end-tidal carbon dioxide, tachycardia, tachypnea, cardiac dysrhythmias, cyanosis, increased temperature or unstable blood pressure.[7] Hommertzheim and Steinke believe that unexplained tachycardia can be one of the hallmarks of MH because it occurs in 96 percent of all reported cases.[1] They also note that although cyanosis is present in 70 percent of patients, skin color first changes to bright red. Another sign of MH would be tightness of other muscle groups, and this can be noted by the surgeon, especially during abdominal surgery.[9] Failure to identify signs of MH until the late stages is detrimental to the patient's outcome.[12] These signs include prolonged bleeding, dark urine, oliguria, and myoglobinuria as well as an increase in creatinine kinase levels.

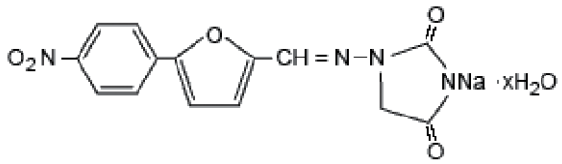
MPD Malignant Hyperthermia Cart with Refrigerator

At the first indication of MH the triggering agent should be stopped. When possible, the surgical procedure is also halted.[1] In order to remove the triggering agent from contact with the patient, the breathing circuit is disconnected from the anesthesia machine, and the unit, soda lime, and patient's airway are flushed with 100 percent oxygen.[1] A MH crisis has similar activity to a cardiac arrest situation, and appropriate alarms are activated to bring additional personnel to the room. Instead of the traditional "crash cart," however, a malignant hyperthermia cart or box is used, which contains a large quantity of dantrolene sodium – the only known agent that is capable of treating MH.[13] The crash cart must also include sterile water (without a bacteriostatic agent) to reconstitute the dantrolene, sodium bicarbonate, furosemide, dextrose, calcium chloride, regular insulin (refrigerated) and antiarrhythmics. If any potent, volatile agents are used, a full supply of dantrolene – 36 vials – should be available on site.[16]

A supply of 36 vials should be stocked at any given time because during treatment of a MH episode, an initial dose of the drug at 2.5 mg/kg is recommended, with an upper limit of 10 mg/kg. If a patient of average weight (eg 70 kg – approximately 155 pounds) requires dantrolene sodium at the upper dosing limit, then at least 700 mg of the drug will be needed. In addition, a review of cases has shown that a "worst case" scenario with a very large patient (eg 100-110 kg – approximately 220-250 pounds) having an acute MH incident, as much as eight-10 mg/kg of dantrolene will be needed for treatment. Even higher doses may be required on rare occasions. Thirty-six vials of dantrolene sodium on site will allow for initial stabilization and treatment while more vials are being acquired to continue treatment as needed.[16]

A vial of dantrolene sodium contains 20mg of the drug, as well as 3000mg of mannitol and sodium hydroxide,

which allows the powder to be reconstituted with 60cc of water.[9] The use of water will speed the reconstitution of the powder, and MHAUS has indicated that warm water can be used to speed the process even further.[11] If the patient does not already have a central venous line placed, one should be inserted so that the dantrolene sodium can be administered quickly and blood can be drawn for analysis.[9, 13]



Molecular composition of dantrolene sodium.

One person is responsible for reconstituting several vials of medicine and passing those vials to another person for administration. The dose varies depending on the severity of the crisis. Reports note that an initial bolus of 2mg/kg is often increased to 10mg/kg or 20mg/kg until the signs of the crisis abate.[9] Hommertzheim and Steinke suggest that a well-stocked MH cart contain no less than 36 vials of dantrolene sodium, and two liters of water.[1]

Because the patient has an increased carbon dioxide level, anesthesia providers should increase the ventilation rate to help provide more oxygen and remove the carbon dioxide.[4] Heggie suggests treating the metabolic acidosis with bicarbonate as well as insulin and dextrose. While controlling the hyperkalemia often resolves any cardiac dysrhythmias, any remaining abnormalities should be treated with appropriate medicines; however, due to the nature of the disease, calcium-channel blockers are contraindicated. Although there is mannitol in the dantrolene sodium vial, additional diuretics, such as furosemide, may be given to increase urinary output and reduce the chance of renal failure.[9]

> As high temperatures can cause further injury and brain damage, it is important to reduce the patient's temperature as part of the crisis management.

Although the crisis is named for the high temperatures generated by the extended muscle contractions, most experts agree that an increase in temperature is one of the last signs presented.[4] Elster, et al, describe increases in temperature from one to two degrees Celsius every five minutes.[8] As high temperatures can cause further injury and brain damage, it is important to reduce the patient's temperature as part of the crisis management. Hommertzheim and Steinke recommend one designated person to control all of the hyperthermia measures. This person should decrease the room temperature and apply ice packs and cooling blankets (or even cool, wet blankets) to the patient's skin (where it does not interfere with the surgical procedure).[1] Anesthesia providers should use refrigerated saline intravenous solution and, if possible, a cold naso-gastric lavage. When the abdominal or thoracic cavities are exposed for the surgical procedure, cool irrigation solution is instilled in the cavities to help decrease core temperature.

POSTOPERATIVE CARE

Dantrolene sodium blocks the release of calcium from the sarcoplasmic reticulum, and when the calcium levels drop, the muscles finally begin to relax.[13] Due to its nature as a muscle relaxant, dantrolene sodium is not without some side effects, such as generalized muscle weakness, phlebitis and respiratory failure.[13] Some patients have also reported gastro-intestinal upset.

After any surgical repairs are completed, the patient is transferred to an intensive care unit for 24-48 hours, where further monitoring can be completed (including electrolytes, creatinine kinase, and urine myoglobin).[9] Rebound crisis episodes are common, and continued treatment with intravenous dantrolene at 1mg/kg every six hours is recommended.[9]

CONCLUSION

MH recently became front-page news with the publication of a story regarding a Florida teenager who died during surgery from a crisis. Early details show that the staff did not act appropriately and may not have delivered enough of the drug in order to fight the disease.[14] Before treatment with dantrolene sodium became common practice, mortality for MH was close to 70 percent. With appropriate treatment, the current mortality rate is less than 10 percent,[1] and some studies indicate mortality as low as five percent.[5] Periodic review of signs and treatment for MH are essential to maintaining the low morbidity and mortality rates.

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Photo courtesy of NASA.

Surgery for Space Exploration

by S Marlene Grenon, MDCM, MMSc, FRCSC
with sidebars by Jodi B Farmer

If space medicine is a field relatively unexplored, space surgery is even more untouched. Space medicine and surgery are the medical and surgical knowledge and skill set needed to support space exploration. With recent great changes in the United States Space Program, but more importantly with a constant push for space exploration, we will need to be prepared to provide sound medical and surgical care to future space explorers. For that, it is imperative that we understand the critical issues that are a challenge in the space environment, their effects on human physiology, the medical and surgical conditions most likely to be encountered during spaceflight, and the set-up for a possible surgical intervention.

Space medicine is considered a subset of space life sciences, which aim to study the effects of the space environment on living organisms. Aerospace physiology aims to understand the effects of the space environment on the human body, while aerospace or space medicine aims to deal with medical issues arising during spaceflight. As a logical extension, space surgery deals with surgical problems that may arise during space travel.

A discussion of the surgical risks would not be contextual without first discussing the risks of the space environment and their impact on human physiology. Several factors of the space environment affect human physiology. These include the linear acceleration, vibration, acoustic noise, reduced atmospheric pressure (and the risk of decompression sickness), weightless-

LEARNING OBJECTIVES

- Compare and contrast normal gravity and microgravity
- Examine the reasons for space travel and exploration
- Define the challenges facing space surgery
- Identify the hazards of space surgery
- Explore the impact of space travel on the human body

ness (microgravity), exposure to extreme temperatures, circadian dyssynchrony, radiation, the risk of impact with micrometeoroids and debris, lunar and martian dust, as well as the closed and isolated environment that can impact the psychological well-being of the space traveler. Hence, several environmental factors have the potential to impact the body's normal function during spaceflight.

We often describe the impact on the human body as "deconditioning." Spaceflight deconditioning affects all body systems and can be debilitating. The cardiovascular system undergoes fluid redistribution to the upper torso and head, which is perceived as a volume overload and in turn leads to a decrease in plasma volume, or hypovolemia. Consequences include orthostatic dysfunction when astronauts return to earth. Other effects include reduced cardiac volumes and mass, decreased exercise tolerance, and an increased risk for arrhythmias. In addition, bone demineralization occurs as a consequence of decreased osteoblast activity, similar to osteoporosis, leading to decreased bone density and increased risk of fractures. This is accompanied by muscle atrophy secondary to the lack of use of postural muscles. The neurovestibular system is also affected leading the most common medical condition experienced by astronauts: space motion sickness. Furthermore, changes occur in the way the body senses posture, position and coordination. In addition to this, immunosuppression, mostly of the cell-mediated type, and post-spaceflight anemia is also encountered in astronauts. Very interestingly, a few reports have hinted to other cellular changes in microgravity, leading to a decreased wound healing. This could have a tremendous impact on the surgical patient. On another note, the possibility of psychological disturbances warrants attention. Experience has shown that normal individuals placed in stressful environments, especially for extended periods, can easily experience abnormal behavior as well fatigue, asthenia, sleep disturbances, and depression. Although researchers and flight surgeons have worked on identifying and treating the causes of spaceflight deconditioning, several issues remain unknown. Furthermore, other yet unidentified conditions may become the real show-stoppers in space exploration. Overall, we have to remember that some of these factors may affect a surgical patient, such as fluid deletion, anemia, immunosupression, radiation, and decreased wound healing.

Photo courtesy of NASA.

NASA's Spitzer Space Telescope has imaged a coiled galaxy with an eye-like object at its center. The 'eye' at the center of the galaxy is actually a monstrous black hole surrounded by a ring of stars. In this color-coded infrared view from Spitzer, the area around the invisible black hole is blue and the ring of stars, white.

The galaxy, called NGC 1097 and located 50 million light-years away, is spiral-shaped like our Milky Way, with long, spindly arms of stars.

The black hole is huge, about 100 million times the mass of our sun, and is feeding off gas and dust, along with the occasional unlucky star. Our Milky Way's central black hole is tame in comparison, with a mass of a few million suns.

The ring around the black hole is bursting with new star formation. An inflow of material toward the central bar of the galaxy is causing the ring to light up with new stars. The galaxy's red spiral arms and the swirling spokes seen between the arms show dust heated by newborn stars. Older populations of stars scattered through the galaxy are blue. The fuzzy blue dot to the left, which appears to fit snugly between the arms, is a companion galaxy. Other dots in the picture are either nearby stars in our galaxy, or distant galaxies.

The most common medical condition experienced by astronauts is space motion sickness.

The surgical risks of the space environment are related to the "occupational risks" inherent to the space environment as well as the surgical conditions that may occur in individuals on a normal basis. The occupational risks include the risks of blunt and penetrating trauma. This could happen during impact with space debris (which is becoming an increasing problem at the environmental level), during

extra-vehicular activity (more commonly called "spacewalks"), during construction and repair of a vehicle or spacecraft, with vehicle docking and refueling, and while servicing payloads. With the advent of the International Space Station and the increasing opportunities for life sciences and other types of research, the risk of chemical contamination and burns is present with electrical equipment repair and chemical or biological research. In the setting of musculoskeletal deconditioning, the risk of orthopedic injuries increases. The risks of minor injuries and dental complaints would be expected, and have, in fact, occurred. Furthermore, the possibility of a "standard" surgical condition, such as appendicitis or cholecystitis, is present. This then leads to the question: should we perform elective appendectomies or cholecystectomies prior to spaceflight? This dilemma remains a subject of debate.

A voyage to Mars would deteriorate bones to osteoporotic levels if no countermeasures, such as exercise, were used.

COUNTERMEASURES THAT WILL MINIMIZE RISKS BEFORE, DURING AND AFTER SPACEFLIGHT[1]

by Jodi B Farmer

	BEFORE FLIGHT	DURING FLIGHT	AFTER FLIGHT
PHYSIOLOGIC EFFECTS (Shift in body fluids)	None	Exercise, use of negative pressure suits for lower body to help with body fluid distribution, isotonic fluid taken orally, use of pressurized anti-gravity suit to help with fluid distribution on re-entry	Use of midodrine (to counter post-flight orthostatic intolerance) is currently being considered
SPACE MOTION SICKNESS	Neurovestibular conditioning including virtual reality training, and parabolic or aerobatic flights and the use of antinauseant medications	Continued antinauseant medications	Intravenous antinauseant and fluids
MUSCLE ATROPHY	Resistance training, aerobic exercise	Aerobic and strength exercise, possible dietary supplementation and electrical muscle stimulation	Muscle conditioning, exercises, massages, icing and use of nonsteroidal anti-inflammatory agents
BONE DEMINERALIZATION	3 DXA (dual energy x-ray absorptiometry) scans per year	Resistance exercises, dietary supplementation including diary, and vitamins D and K	2 DXA scans within 6 months after space mission, 4 DXA scans over 3 years afterward, temporary restriction of activities such as flying high-performance jets
PSYCHOSOCIAL EFFECTS	Meeting recruitment criteria and specific behavioral competencies, didactic training including teamwork and field-based training	Individualized work schedules, 8 hours of rest daily, short-acting hypnotics to prevent sleep loss and modafanil to enhance performance after periods of reduced sleep	Psychological debriefing sessions
IMMUNE DYSREGULATION	Quarantine program for 1 week before flight	Exposure to artificial gravity and nutrition supplements are currently being considered	Collection of biological samples to measure immune function

WHAT IS MICROGRAVITY?

by Jodi B Farmer

Microgravity is basically just free fall. On Earth, gravity governs us and motions throughout the universe. It holds us to the ground and keeps the moon in orbit around Earth and other plants in orbit around the sun.

Although most people think that there is no gravity in space, the gravitational field is quite strong and this field keeps planets and the moon in orbit. That is how orbiting spacecraft, such as a space shuttle or the space station are kept in orbit around Earth, by gravity.

More than 300 years ago, Sir Isaac Newton first described gravity. He wrote that gravity is the attraction between any two masses, which is most apparent when one mass is very large. An example would be Earth (large) and space shuttle (small). The acceleration of an object toward the ground is called "normal gravity," which is what humans experience on Earth.

In space, objects are actually falling as well. If an astronaut drops something in the space station, it falls although it looks like it is floating. This optical illusion of the item floating is because everything is falling together: the astronaut, the item and the space station. But instead of falling down toward Earth, they're all falling around it at the same rate, which gives off the appearance of floating. This phenomenon is called zero gravity or microgravity.

Microgravity can be felt here on Earth. Some amusement park rides are actually called free-fall rides that give off the feeling of microgravity. Most roller coasters create brief periods of weightlessness when they go through the rolling hills of the ride.

NASA also has created two drop towers at its Zero Gravity Research Center in Brook Park, Ohio, that allows objects to free fall from 2 to 5 seconds so researchers can study the effects of weightlessness.

Microgravity's Impact On The Human Body[4,8]

Microgravity is the most profound aspect of the space environment on human physiology. All organ systems are affected when living in a space environment, but there are two major challenges associated with humans who live and work on a space flight: radiation effects and the physiologic consequences of being in a microgravity environment.

Much of the risk of injury or poor wound healing is due to the effects of microgravity. Once in weightlessness, people, objects or structures could cause crushing or lacerating blows because they retain their full mass in microgravity. Since microgravity gives the appearance of lack of weight, humans operating in space can misjudge and misread how much things weigh and end up pushing them to hard throughout the craft or bumping into them. Because of this insensitivity to mass judgments trauma is a major concern during the space flight.

Prolonged exposure to a microgravity environment is also a concern during space missions. It has been shown to decrease bone density, increase head edema (swelling of the brain), reduction in cardiac stroke volume, enlargement of liver and pancreas as well as the reduction in red blood cells. The risk of kidney stones and loss of proteins are also major concerns. Since proteins are essential to maintaining how the body works, and since the body has no space proteins, the loss of them could be debilitating. Proteins help with one's muscle function, cell structure and immune responses. Bed rest studies show a person's protein loss is usually about 15 to 20 percent wherein space protein loss can be a devastating 45 percent decrease.

The risk of radiation to space travelers is great. The occurrence of large solar particle events, also known as SPE, usually is associated with high levels of solar activity. When one is exposed to high doses of solar radiation one may experience acute radiation syndrome. Side effects include nausea, vomiting, hemorrhaging, or even death. Understanding how to prevent radiation sickness will be necessary to help lower radiation risks while in space.

Microgravity also has strong effects on cells and how they grow. Cells use a tension-dependent form of architecture, known as tensegrity. The level of a pre-existing tension is known as pre-stress. Gravity plays a large part in contributing to pre-stress within individual cells. When one enters and lives in a microgravity environment, the cells experience an acute decrease in pre-stress. In a space-like environment, where gravity is non-existent, a cell is less likely to divide and grow, which contributes to slower wound healing and presents more difficulty in treating patients during space flight.

Photo courtesy of NASA.

Astronauts Joan E. Higginbotham (foreground), STS-116 mission specialist, and Sunita L. Williams, Expedition 14 flight engineer, refer to a procedures checklist as they work the controls of the Space Station Remote Manipulator System (SSRMS) or Canadarm2 in the Destiny laboratory of the International Space Station.

At the present time, our diagnostic capability is mostly limited to history taking, physical examination and ultrasound. This can be supplemented by telemedicine, although we have to remember that for a flight away from Earth (ie Martian exploration), the time to communicate with mission control may be in the order of 0.5 hours, limiting our ability to have real-time feed-back, which may be critical. The capability to provide basic life support that includes obtaining an airway and ventilation, as well as the performance of cardio-pulmonary resuscitation, has been established in analog environments of weightlessness. Astronauts have, in fact, had the opportunity to practice these skills on the International Space Station, although they have not been applied in a real emergency.

For anesthesia, local and intravenous anesthetic agents appear to be the preferred methods for major operations during spaceflight because of potential risks associated with inhalational anesthetics and spinal anesthetics. With the proper equipment (sterile drapes, sutures, instruments, operating table) and restraining system (for patient, surgeon and equipment), surgical techniques can be performed in microgravity. Some critical aspects however have remained poorly investigated and may represent challenges for successful surgical care. These include aspects related to pharmacodynamics, pharmacokinetics and bioavailability (particularly in the setting of fluid shifts known to occur in microgravity), wound healing, and the effects of immune-suppression and radiation on post-operative infection. Finally, the most appropriate training and skill-set maintenance for the future space surgeon is also unclear.

Konstantin Tsiolkovsky, who is considered the father of Cosmonautics once said: "Earth is the cradle of mankind, but one cannot stay in the cradle forever." In the coming centuries, we are likely to face some major uncertainties such as the availability of food to supply world's burgeoning population, the reserves of energy sources for our expanding economies, and the effects of pollution on our environment. Although space exploration may seem like an extravagance now, it may become the key to assuring our survival as a species. Space medicine and surgery becomes an important facet to this endeavor. Several important milestones have been reached with regards to surgical care in space but certain areas still remain to be developed. It will be critical to address these issues in the coming years and decades, particularly in order to keep humankind's leap out of its cradle as a safe journey.

ABOUT THE AUTHOR

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Although space exploration may seem like an extravagance now, it may become the key to assuring the survival as a species. Space medicine and surgery becomes an important facet to this endeavor.

THE EFFECTS OF SPACE TRAVEL ON THE HUMAN BODY

by Jodi B Farmer

Before one can understand the effects of space travel on the human body, one must understand how the term acclimation is used. Acclimation is defined as acute changes in normal physiology in response to abnormal environments. Two lengths of time are typically measured: short-term exposure (hours to days), and long-term exposure (days to months). A space traveler's ability to adapt to acclimation plays a large part in their wellbeing while in space. Microgravity has the largest effect on human physiology and all organs are affected to some degree.

Cardiovascular, neurovestibular, musculoskeletal, immune deficiencies and psychosocial differences are the most common changes one goes though while participating in space travel. The effects of microgravity also play a part in changing cells and their structure, which also leads to adaptations in surgical procedures. Radiation exposure also plays a part in how a space traveler will feel during the space mission. The most critical conditions, however, may be unidentified conditions, as medical experts would have to quickly and effectively treat these symptoms without much knowledge of why they are being caused. With some areas of weightlessness not yet thoroughly understood, unidentified conditions may pose the highest risk of space flight.

CARDIOVASCULAR CHANGES

Hypovolemia occurs when fluids are redistributed to the upper torso and head, causing a decrease in plasma volume. This is due to the supine prelaunch position that sets the lower limbs above the torso and head. This position during launch, which continues into orbit, initiates a fluid shift where the body's fluids move toward the head. In space, where the pull of gravity is missing, the head-to-toe gradient of blood pressure vanishes. This effect results in facial fullness and a puffy appearance of the head. The changes of cardiovascular systems in microgravity suggest a more complex process of acclimation. When the body's fluid shifts upward toward the head, the baroreceptors of the central vasculature triggers suppression of the renin-angiotension-aldosterone system, releases atrial natriuretic peptide and reduces the plasma volume. The release of atrial natriuretic peptide leads to an increased renal excretion of salt and water. The decrease of the plasma volume appears to also decrease the erythropoietin secretion, which leads to a reduction in red blood cells. The effect of the reduction is about 10 percent less in a space traveler's total blood volume.

These changes also contribute to landing-day orthostatic stress. When the travelers reenter the Earth's orbit, their body fluids pool back into the vasculature of the lower body and create great stress on the body. It has been shown that typically one in four astronauts is unable to stand for 10 minutes within hours of landing because they exhibit body redistribution systems including light-headedness, heart palpitations and syncope, also known as fainting. To decrease the risk of landing-day orthostatic stress, it is advised that space travelers continue to participate in aerobic capacity and use techniques and devices that help redistribute body fluids before landing.

NEUROVESTIBULAR CHANGES

Neurovestibular acclimation occurs in most astronauts and usually affects them during the first couple days after arriving in space. Predominant symptoms may include facial pallor, cold sweating, nausea and vomiting. The same symptoms can also occur during the reacclimation period when astronauts return to Earth. The most common motion sickness usually occurs when astronauts first begin to work in the weightlessness environment of space. The redistribution of body fluids that occurs on entry into microgravity may account for some early symptoms of space motion sickness. Because the autonomic nervous system, gastrointestinal system, neurovestibular system and cardiovascular system are all affected, a range of symptoms are usually reported. These symptoms are usually short-lived, with most space travelers showing improvement within two to three days. These neurovestibular conditions also usually occur for one to two days after returning to Earth and, in some cases, have required intravenous drug and fluid treatment upon arrival after landing. Other changes within the neurovestibular systems include the way the body senses posture, position and coordination.

MUSCULOSKELETAL CHANGES

One of the most common changes in the human body during space flight is the change in muscle mass. During flight, muscles lose mass and strength with the postural muscles being the most affected. The postural muscles allow our bodies to maintain an upright position in a gravitational environment. Studies show that after two weeks in space, muscle mass is diminished by as much as 20 percent. Muscle atrophy, defined as decrease in muscle size and wasting away of a body part or tissue, happens because of the absence of gravitational loading during space flight. Muscle unloading results in biochemical and structural changes and affects the posture and position of astronauts. It also can greatly affect coordination of space travelers, which could have a huge impact on medical experts when traveling in space. Muscles may also be affected by suboptimal nutrition as well as stress while aboard the space craft during flight.

After returning to Earth, astronauts' deconditioned muscles are again affected by gravitational forces and most travelers report muscle soreness, tight muscles and stiff joints. Preflight exercise and exercise during space flight proves helpful to space travelers, although it does not fully prevent muscle loss. Through muscle conditioning and rehabilitation programs after returning to Earth, tests show that most space travelers will recover their strength and regain their full muscle mass within in one to two months.

Another condition affecting the human body during space flight is the microgravity pull on bones and the loss of bone density. Bone demineralization occurs as a consequence of decreased osteoblast activity, similar to osteoporosis, leading to decreased bone density and increased risk of fractures. This is accompanied by muscle atrophy secondary to the lack of use of postural muscles. Bone demineralization begins the first day in space and prompts the concern for increased fractures during and after space flight as well as a complete loss of bone density. According to NASA, a voyage to Mars would deteriorate bones to osteoporotic levels if no countermeasures, such as exercise, were used. Some of the bone loss would be so great that osteoblasts (a cell that makes bone) would be unable to rebuild the bone upon returning to Earth. Although severe, NASA found that most astronauts fully recover their bone density within three years although some never regain the bone density they lost in space.

IMMUNE DYSREGULATION

A few reports have hinted to other cellular changes in microgravity, leading to a decreased wound healing. This could have a tremendous impact on the surgical patient. Space travelers' immune systems are affected by the pressure of space, and astronauts have reported bacterial or viral infections that occurred during flight or after returning to Earth. Researchers think that astronauts' immune impairment before and after space flight is the result of high levels of physical and psychological stress endured during the flight. Some of the effects for impairment during space travel may include physiologic stress, isolation, confinement, and disrupted circadian rhythms. The impairment of cell-mediated immunity could lead to a change in a space traveler's immune system. Also, astronauts' immune systems after landing have shown many changes, including redistribution of circulating leukocytes, decreased activity of natural killer cells, decreased activation of T cells, varying levels of immunoglobulins, as well as other virus-causing changes. All of these changes could lead to autoimmunity, allergies, infectious and even malignant diseases.

PSYCHOLOGICAL DISTURBANCES

Because the space-flight environment is unique with temperature extremes, circadian dyssynchrony, isolated and confined living quarters and abnormal acoustic noise, space travelers face unique obstacles to maintaining any kind of normal routine, especially a normal sleep schedule, which may greatly affect one's mental and physical performance in space. Throughout space flights, NASA has noticed that astronaut's emotional states remain mostly positive with the exception of some discord with interrupted sleep patterns. Fatigue increases the chances that one in space flight could make an error and decreases the capacity of space travelers to deal with adversity, frustration and interpersonal changes. Since the risk of surgery is already at a heightened state, sleep deprivation would definitely impact surgeries being performed in space. Due to the tight and isolated living arrangement on such space flights, travelers would also need to be checked for claustrophobic tendencies as well as being constantly screened for depression.

CHALLENGES FACING SPACE SURGERY

Technological limitations affecting the physical space aboard the craft would strictly limit how much equipment would be allowed. Equipment and tools would need to be restrained and there would also need to be restraints for the patients, surgeons and operative staff.

Other obstacles for performing surgery in a microgravity environment would include a limited amount of water and other supplies, disinfection of equipment, adjusting to new aseptic techniques, safe removal of hazardous material, and the stability and mobility of the persons performing the procedure. The risk of contamination is high and new procedures would have to be followed to make sure the patient and others on the craft would be free of contaminants following the procedure. After surgery, risk of infection would be higher than it is on Earth. Since microgravity greatly slows down wound healing, surgical patients would have to be constantly watched to make sure they remain stable.

Another option would be to have a robot on board to help with any operations. Robotic assistants already assist surgeons on Earth with a number of minimally invasive surgical procedures. Advanced versions of the robotic surgical assistants could help surgeons carry out procedures in space. The steady grip of a robotic arm increases the safety of endoscopic procedures and would limit the risk of contamination following a surgery in space.

Overall, many factors may affect a surgical patient, such as fluid deletion, anemia, immunosupression, radiation, and decreased wound healing. Studies of operative procedures have shown increases in force and volume of venous bleeding in microgravity when compared to normal gravitational environments. Patients would also have to be watched when returning to a gravitational environment to lower the risk of future complications.

For now, it seems minor surgeries have a greater chance at succeeding while being performed in a space setting. For complex surgeries such as an appendectomy researchers are in debate about whether to perform these elective surgeries before one travels to space to reduce the risk of performing such surgeries in a space environment. Providing basic life support remains the most important issue of caring for space travelers. Continued extensive training will be necessary to learn the best and most effective ways to perform surgical procedures in space. Researchers still need to do more work to see how cells react in microgravity to gain a better understanding of more complex processes such as wound healing and bone and muscle physiology. If future space travelers can train within simulated microgravity environments, more medical experts will have a greater understanding of a wider set of medical questions and what needs to be done to decrease one's surgical risk during space travel.

ADVANCES IN MEDICAL TECHNOLOGY THAT HAVE RESULTED FROM SPACE EXPLORATION

by Jodi B Farmer

Space exploration is not just for exploring space and finding possible future habitats. It also has produced many benefits that assist in the quality of life on Earth. Many of the technological applications needed for space flight have helped improved humans' lives as well. One example includes the Hubble Space Telescope. The Charge Coupled Device (CCD) chips for digital image breast biopsies is one spinoff created from the telescope. The LORAD Stereo Guide Breast Biopsy system uses CCDs as part of a digital camera system. The device can view breast tissue more clearly and efficiently that any other existing technologies and are so advanced that they can detect the smallest differences between malignant or benign tumors without a biopsy. Since more than 500,000 women every year need breast biopsies, this technology has not only allowed for a less invasive and traumatic procedure, but has created economic benefits as well by reducing the cost and time of the procedure.

At about 100 meters from the cargo bay of the space shuttle Challenger, Bruce McCandless II was further out than anyone had ever been before. Guided by a Manned Maneuvering Unit (MMU), astronaut McCandless, pictured above, was floating free in space. McCandless and fellow NASA astronaut Robert Stewart were the first to experience such an "untethered space walk" during Space Shuttle mission 41-B in 1984. The MMU works by shooting jets of nitrogen and has since been used to help deploy and retrieve satellites. With a mass over 140 kilograms, a MMU is heavy on Earth, but, like everything, is weightless when drifting in orbit. The MMU was replaced with the SAFER backpack propulsion unit.

Other space technology spinoffs also have improved the lives of mankind. Laser angioplasty offers fewer complications and a more precise nonsurgical cleaning of clogged arteries than a balloon angioplasty. The ultrasound skin damage assessment uses NASA technology to survey damage depth of burn patients. Using NASA's technology, the programmable pacemaker allows the implant and physician's computer console to communicate through wireless telemetry signals; and a cool suit circulates coolant through tubes to lower a patient's body temperature. This technology made from space suits helps improve the conditions of multiple sclerosis, cerebral palsy, and spina bifida.

Through NASA teleoperator and robotic technology, a voice-controlled wheelchair and manipulator responds to 35 one-word commands that helps patients perform daily tasks, such as turning on appliances and opening doors. Other space technology advances include the human tissue stimulator, which helps a patient control chronic pain and involuntary motions through electrical stimulation; ocular screening, which helps detect vision problems in young children; the medical gas analyzer that monitors operating rooms for the amount of anesthetic gasses and measurements of oxygen, carbon dioxide, and nitrogen during surgery; as well as portable X-ray devices, invisible braces, MRI equipment, bone analyzers, and cataract surgery tools.

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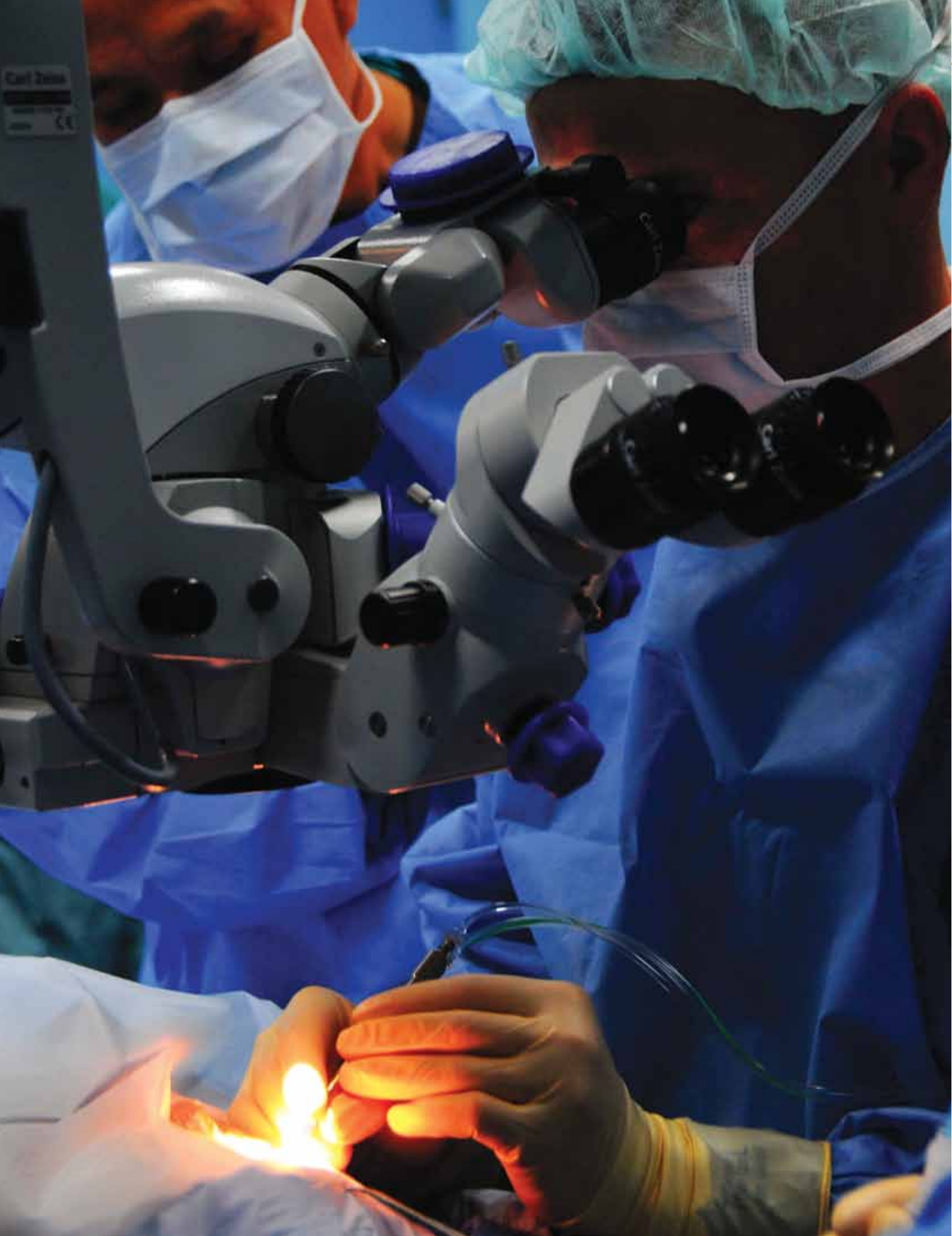


Cannulated Retinal Surgery

by Donna Mrugala, CST, BS

The eye is one of the most complex organs of the human body. There are many small structures within the eye that work together to form the basis for one of our most valued senses – sight. When the eye is compromised or damaged, surgical intervention may be needed to repair it. Cannulated retinal surgery is one of the most common procedures performed on the eye.

ANATOMY OF THE EYE

The sclera, or white of the eye, is the outermost part of the eye. It is approximately 1 mm of tough, opaque, white connective tissue. The sclera's job is to protect the eye and provide support and structure. It extends posteriorly all the way to provide an opening for the optic nerve. The sclera is attached to tendons that connect to four primary muscles and two oblique muscles that move the eyeball.

The choroid is a layer of blood vessels and connective tissue that is situated between the retina and the sclera. It is part of the uvea and supplies nutrients to the inner parts of the eye. It connects with the ciliary body toward the front of the eye and is attached to the edges of the optic nerve at the back of the eye.

The conjunctiva extends from the limbus (also known as the pars plana) of the cornea and covers the exposed area of the globe. It folds back onto the inner surfaces of the eyelids. The pars plana is an avascular area that is clear of major intraocular structures.

The front covering of the eye, or cornea, is a translucent structure that is approximately 0.5 mm thick. Together with the sclera,

LEARNING OBJECTIVES

- Review the relevant anatomy for this procedure
- List the required equipment for pars plana vitrectomy
- Evaluate the step-by-step process of pars plana vitrectomy
- Assess the possible risks and complications associated with this procedure
- Explore advancements in the field of eye surgery

the cornea makes up the outermost layer of the eye. It is composed of five, distinct layers: the epithelium, Bowman's membrane, stromal, descemes and the endothelium. The cornea is avascular unless the patient is afflicted with blood vessel neo-vascular disease. The cornea allows light to be bent and focused on the retina.

A pars plana vitrectomy (PPV) involves the surgical removal of foreign matter or blood from the vitreous. In some instances, it can include the removal of the vitreous itself.

The uvea, or uveal tract, is made up of three parts: the iris, ciliary body and choroid. The uvea provides the main blood supply through this vascular compartment of the eye. The iris is the colored muscular diaphragm that opens and closes in front of the eye. The ciliary body is a band-like structure that encircles the inside of the sclera toward the front of the eye, and the choroid is a continuation of the ciliary body in the form of a layer of tissue that lies between the sclera and the retina. It is made up largely of blood vessels that nourish the outer layers of the retina.

The crystalline lens is a transparent structure that is centered immediately behind the iris and suspended in the posterior cavity. It is held in place by transparent fibers called zonules that radiate from the lens and attach to the ciliary body. Tiny muscles within the ciliary body can change the tension on the zonules. When these muscles, the ciliary muscles, are stretched tight, the lens is flattened, allowing for distance vision. When the muscles are relaxed, the lens is rounded for near vision. The change in shape of the crystalline lens to allow for near and far vision is called accommodation.

The vitreous is a clear, jelly-like substance that fills the posterior chamber of the eye. This connective tissue helps maintain the global structure of the eye. It is optically transparent and may liquefy as part of the aging process, occasionally producing small clumps or strands of concentrated gel floating in the now-fluid vitreous. These particles are called floaters.

The retina itself is a transparent layer of tissue that forms the innermost lining of the globe. This layer consists mainly of nerve cells, and is actually an extension of the brain. The retina is composed of an inner layer of nerves containing two types of photoreceptors (or light sensitive cells): the rods and the cones. Rods are responsible for both night and peripheral vision. The cones are used during the day and interpret sharp images and color perception. The central retinal artery enters and the central retinal vein exits at a location called the optic disc or the optic nerve head. There is no vision at the optic disc. The macula, which is located close to the center of the retina, is a specialized area because most of the cone cells are concentrated there for the proper function of this area, which is crucial to finely-detailed central vision. The area of sharpest vision is the fovea centralis. The optic nerve is stimulated by light to the rods and cones in the retinal photoreceptor layer. The resulting electric (nerve) impulses are relayed to the bipolar cells, which lie above the rods and cones. The impulses pass to ganglion cells at the top, or inner-most layer, of the retina. These ganglion cells possess long, fiber-like axons, which course over the retina and converge at the optic disc at the back of the eye. The axons from the ganglion cells form the optic nerve.

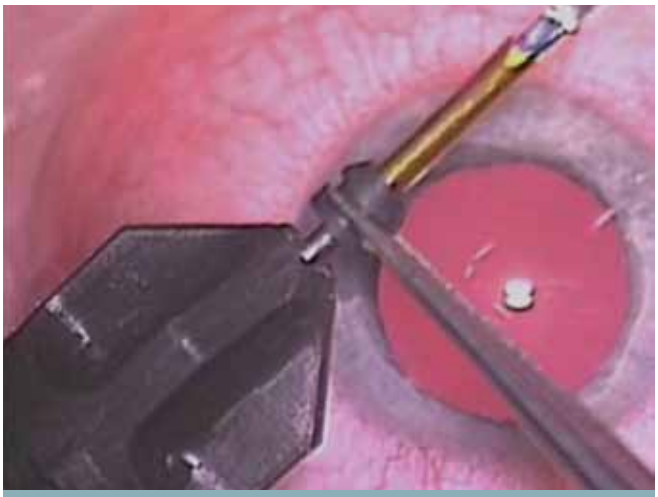
Brunch's membrane is a thin, cell-free membrane made up of sheets of connective tissue. It separates the choroid from the retina while allowing nutrients to pass through. It naturally thickens with age and defects in the membrane can develop in diseases such as age-related macular degeneration (AMD) and severe myopia, or nearsightedness.

The retinal pigment epithelim (RPE) is located at the outermost layer of the retina, adjacent to Bruch's membrane. It serves as a barrier between the choroid and the retina and provides nourishment to the eye. RPE cells contain pigment granules, which absorb excess scattered light that might otherwise strike the photoreceptors.

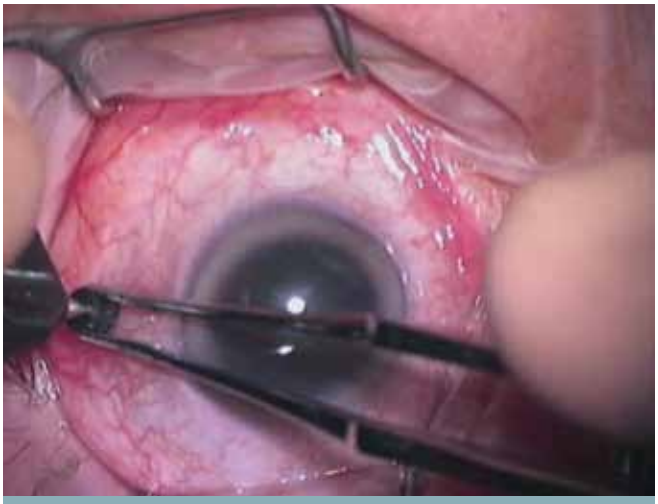
PROCEDURE OVERVIEW AND EQUIPMENT

A pars plana vitrectomy (PPV) involves the surgical removal of foreign matter or blood from the vitreous. In some instances, it can include the removal of the vitreous itself. This procedure removes scar tissue, membranes and traction, restoring the retina to its normal physiologic position. The surgeon may opt for a biopsy of the vitreous for diagnosis before treatment.

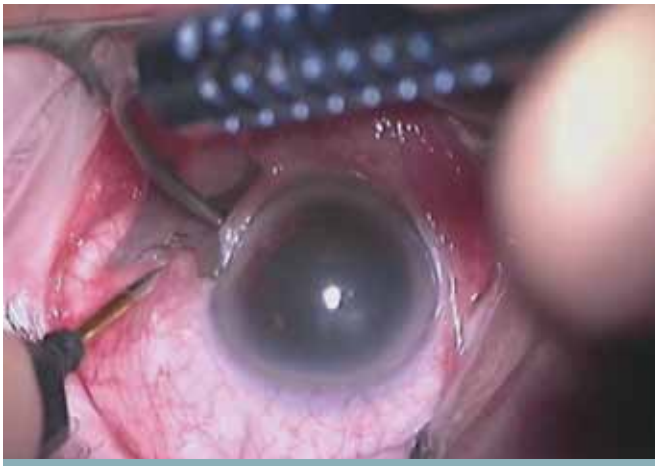
Some of the required equipment includes a Binocular Indirect Ophthalmomicroscope (BIOM) for panoramic



The trocar blade and outside cannula are held with a trocar cannula forceps.

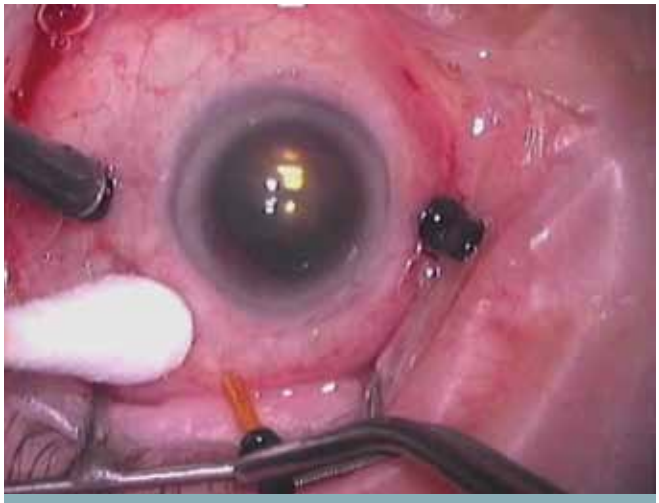


The trocar and cannula are measured on the sclera 3-3.5 mm from the limbus cornea so that the conjunctiva falls back, covering the wound, when the cannula is removed.



The trocar blade and cannula are insterted into the globe 3-3.5 mm from the limbus.

Three ports are used for the vitrectomy surgery. One is for the infusion used to maintain the globe. This port connects to a special adaptor and fine 20-gauge tubing that connects to a stopcock. The three-way stopcock connects the infusion port in the eye to the macro drip tubing to a bottle of BSS, and the third port is for an air line if one is needed.



Removal of the cannulas using Nugent forceps.

At this time, while the smaller-gauge instruments (23- and 25-gauge) continue to evolve and show promise, certain cases may require larger gauge instrumentation.

viewing; a computer-programmed vitrectomy machine; an indirect ophthalmoscope; and endolaser and indirect laser.

The patient is placed in the supine position and the patient cart is positioned for optimum microscope usage. The patient receives retrobulbar anesthesia, which is composed of 4 ml bupivacaine (0.75 percent), 4 ml of plain lidocaine (two percent) and 30 U vitrase 0.2 ml in a 10 ml syringe with a 25 gauge 1.5-inch needle. Proparacaine drops are administered to the operative eye prior to injection or prep.

The patient is prepped with betadine paint (10 percent) mixed with saline in a 1:1 ratio. The operative eyelashes are cleaned using cotton swabs dipped in the betadine paint mixture. The operative eye and surrounding orbit are then painted in the same manner.

THE PARS PLANA VITRECTOMY PROCEDURE (19- AND 20-GAUGE)

In 1981, vitrectomy was done using a 19-gauge ocutome probe that required disassembly and reassembly to clean. By the late 1980s, surgeons were working with disposable 20-gauge probes. The Accurus machine – a computer-operated device—appeared in 1995. It also featured a 20-gauge probe and introduced a higher cut rate. The cut rate began at 600 cuts per minute (cpm), then was upgraded to 1,800 cpm and finally to 2,500 cpm.

To begin the procedure, the surgeon cuts down into the conjunctiva at three sites in order to expose the sclera three to four mm from the limbus, also known as the pars plana. Vessels are cauterized as needed. One of the cut sites maintains the integrity of the globe by use of infusion. The other two are the insertion points for instrumentation into the eye: a vitector and a light source.

Next, a 20-gauge infusion cannula is sutured into one sclerotomy, usually in a lateral position, and the line is taped down to the drape in order to prevent any unnecessary or inadvertent movements when the lights are off in the room. Placement is checked before infusion is turned on to verify location.

The surgeon then completes the two remaining sclerotomies and inserts 19-gauge or 20-gauge plugs. The plugs are inserted to maintain pressure within the globe. The illumination probe, which provides a fiber-optic light source to provide light when the microscope light is turned off, and the vitrector, which is used for cutting the vitreous, are inserted to begin the procedure.

Once the vitrectomy is complete, the surgeon closes the two sites where the surgical instruments were placed with either 8-0 polyglactin, 910 suture or 6-0 plain suture on a TG140-8 needle. Plugs are used to maintain pressure in the eye as one port after the other is closed. Finally, the infusion cannula is removed and that site is sutured shut. Upon removal of infusion, the ability to maintain the globe pressure rests on the suture sites.

The surgeon checks and adjusts the intraocular pressure and balanced salt solution (BSS) is injected with a 30-gauge needle if the eye is too soft.

The conjunctiva is closed, completing the tissue closure. Cycloplegic or mydriatic ointment (antibiotics) and steroid drops are injected to decrease the chance of infection or inflammation. A patch and shield is applied to protect the eye from possible injury.

PARS PLANA VITRECTOMY PROCEDURE (23- OR 25-GAUGE)

Using a caliper, the surgeon marks the insertion site three to four mm from the limbus and, using 23- or 25-gauge trocar cannulas, inserts the infusion cannula into the globe, stabilizing the eye with an applicator. The infusion cannula is checked before the infusion is turned on to verify proper position. The infusion line maintains pressure in the globe. If the surgeon is using a pressure plate with a caliper, it is done together.

The other two ports are entered and the plugs are inserted to maintain pressure in the globe when the globe is cannulated. The plugs are removed one at a time and the illumination probe is inserted first, followed by the vitrector. The illumination needs to be inserted first and turned on in order to begin surgery. The vitrector is inserted second. After the procedure is completed, the cannulas are removed one at a time, with the infusion line being removed last. The sites are checked for leakage and sutured if necessary.

POSTOPERATIVE RECOVERY

The patient will wear an eye patch for the first night following the procedure. The surgeon likely will remove the eye patch the day after surgery, but it is recommended that the patient wear sunglasses or prescription glasses during the day and a protective eye shield over the operative eye while sleeping for the first week postoperatively. Some pain or discomfort is normal after the procedure. Narcotic pain medication may be prescribed for pain in the first few days following surgery, but NSAIDs should be sufficient to control discomfort shortly thereafter. A moderate amount of drainage can be expected during the first week postoperatively and will gradually decrease.

Patients will be discharged with several eye drops or ointments. One medication is a mydriatic, or dilating drop, used to keep the eye dilated. Another drop is an antibiotic, which may be combined with a steroid, to prevent infection and promote healing. Occasionally, a third drop is used to control the pressure in the eye. The eye drops and ointments are typically used for four to eight weeks.

CONCLUSION

Historically, 20-gauge vitrectomy has been both well tolerated and effective with high rates of successful outcomes and low rates of complications, such as endophthalmitis, an inflammatory condition of the intraocular cavities (aqueous or vitreous) usually caused by infection. Noninfectious, or sterile endophthalmitis may result from various causes such as retained native lens material after an operation or from toxic agents.

There are two types of endophthalmitis: endogenous and exogenous. Endogenous endophthalmitis results from the hematogenous spread of organisms from a distant source of infection. Exogenous endophthalmitis results from direct inoculation as a complication of ocular surgery, foreign bodies and blunt or penetrating ocular trauma.

For more than 30 years, 20-gauge vitrectomy has been the standard of care, and as such, most vitreo-retina surgery instruments have been designed for 20-gauge instrumentation.

At this time, while the smaller-gauge instruments (23- and 25-gauge) continue to evolve and show promise, certain cases may require larger gauge instrumentation. Membranes, sometimes referred to as scar tissue in diabetic eyes, can be found connected to the retina and can be very proliferative. Membranes also can cause macular holes by tugging on the macula creating a macular hole. When membranes are removed for retinal detachments, it allows the retina to reattach. When the membranes are removed that are responsible for macular holes, the patient's fine-focus area of the eye is allowed to heal, improving vision.

Bimanual technique requires a light source to be inserted into the globe that the surgeon does not hold. This allows the surgeon to use scissors and forceps together on very prolific membrane eyes, shortening operating time.

When using proliferative vitreoretinopathy, membrane peeling, or when bimanual techniques are used, it may be advantageous to consider 20-gauge vitrectomy procedure. More instrument options are available for 20-gauge vitrectomy versus 23- or 25-gauge vitrectomy. Traction retinal detachments sometimes require huge retinectomies that utilize a membrane peeling cutter (MPC), which can be useful for segmenting or delaminating. The MPC is only available in 20-gauge.

Crystalline lens or retained lens material after cataract surgery is removed typically with 20-gauge fragmenting instrumentation. Fragmentation is only available in 20-gauge. Thus, when it is necessary to remove the crystalline lens, because of cataract or dislocation, fragmentation with 20-gauge instrumentation is the most efficient means to do so. If only small cortical pieces are present, 25- or 23-gauge vitrectomy without fragmentation may be sufficient. However, when large amounts of nuclear material or dense nuclear material are present, 20-gauge vitrectomy with fragmentation is usually necessary.

Removal of silicone oil (whether 1,000 or 5,000 centistoke oil) becomes a challenge through a 23- or 25-gauge for aspiration and replacement of oil with BSS. Fluids involved in exchange of different liquid densities require higher pressures to maintain the globe. Complications and risk in globes becoming soft are choriodal hemorrhages. Ischemic changes can occur after surgery as well.

While efficiency and patient comfort are great reasons for using smaller gauge vitrectomy instrumentation, drawbacks do exist besides to use 20-gauge vitrectomy surgery. The steps involved in opening the conjunctiva and closing it add to patient discomfort and increase corneal astigmatism. A 20-gauge, trocar-based sutureless system is currently on the market. The purpose of par plana vitrectomy with a 20-gauge transconjunctival cannulated sutureless (TCS) is combining the advantages of smaller-gauge trocar cannulas with economical advantage of not needing to purchase additional handheld instruments. However, sclerotomies are larger and self-sealing sclerotomies may not be as easily done.

Like the smaller gauge, the 20-gauge transconjunctival sutureless vitrectomy is associated with complications that include premature dislodging of cannula, retinal tear, hypotony, hemorrhagic choroidals, subconjunctival gas and less-than-full gas fill. A possibly higher sclerotomy suturing rate, relative to smaller-gauge approaches, is a disadvantage of this technique.

In the effort to improve comfort and to increase operative efficiency the smaller gauges were presented.

ABOUT THE AUTHOR

Donna Mrugala, CST, BS, has worked as a surgical technologist since 1975. She spent five years at St Joseph's Hospital in Milwaukee before spending six months abroad studying at Jagellonian University in Krakow, Poland. She returned to Milwaukee County, where she began working in ophthalmology and has remained in this discipline, where her sub-specialty is vitreo-retinal surgery. Ms Mrugala has a BS in biology and conservation and has participated in health care volunteer projects at home and abroad.

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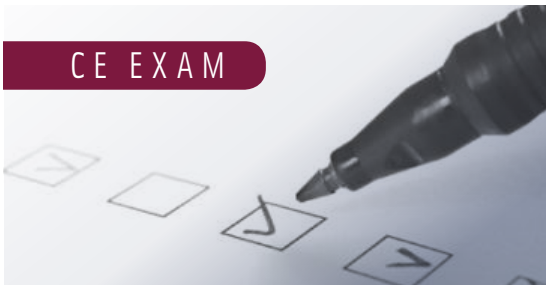

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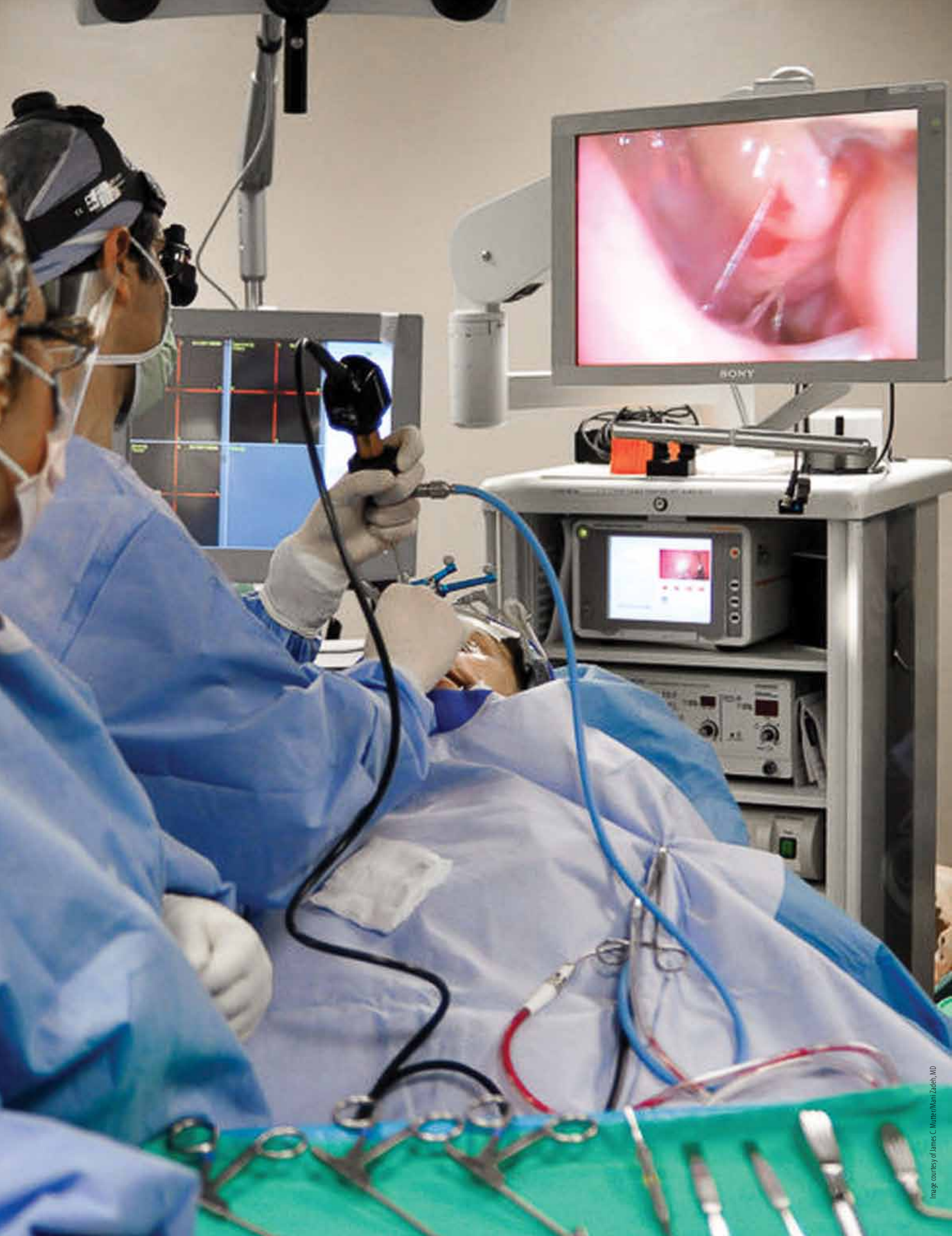


Image courtesy of James C. Mutter/Mani Zadeh, MD

INNOVATIONS IN

Endoscopic Sinus Surgery

by Theresa Criscitelli, CST, RN, MS, CNOR

Endoscopic sinus surgery (ESS) has undergone exponential growth worldwide in the last two decades. Technology is advancing rapidly and it is the job of all healthcare professionals to keep abreast of changing technology in order to provide patients with current, safe, and effective treatment options. Approximately 37 million Americans suffer from sinusitis every year and it is one of the most common reasons for visiting a primary care physician.[5] Sinusitis decreases one's quality of life and restricts activities which can further escalate into sinus infections and chronic headaches.

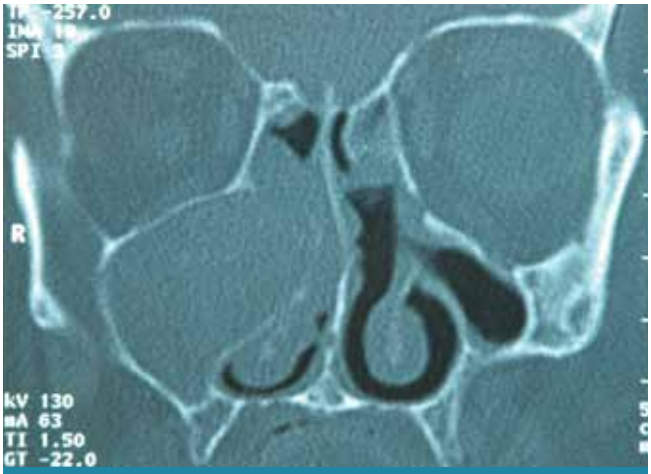
ESS is the examination of the nasal cavities through an endoscope with the possible resection of inflamed nasal tissue and the correction of anatomical defects in the sinuses. The goal is to ensure ventilation and restore mucociliary clearance, ultimately preventing sinus infection.[4]

HISTORICAL RELEVANCE

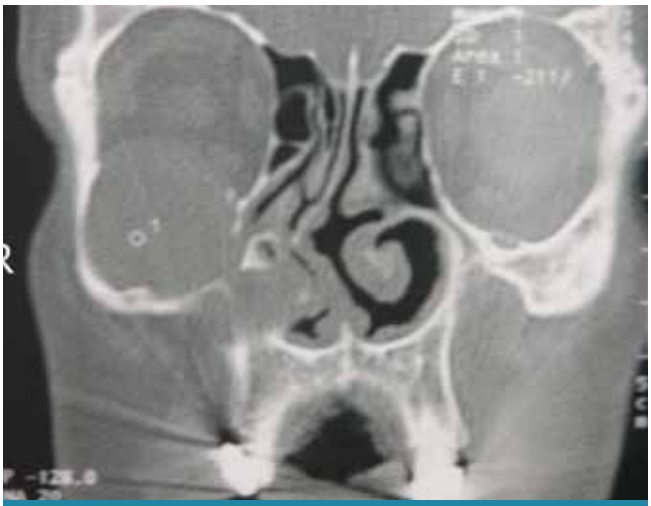
Endoscopic sinus surgery procedures originated in the late 1970s in Germany and Austria and were brought to the United States in the mid 1980s.[3] In 1990, the use of sinuscopes, coupled with computer imaging modalities, redefined this surgical approach aiding in more thorough preoperative planning, safer and more precise surgical dissection with minimally invasive trauma to nasal tissue. This procedure helps to accelerate postoperative healing. Traditional craniotomies have become obsolete for selective lesions that now can be accessed via trans-sinonasal and transcranial endoscopic routes.

LEARNING OBJECTIVES

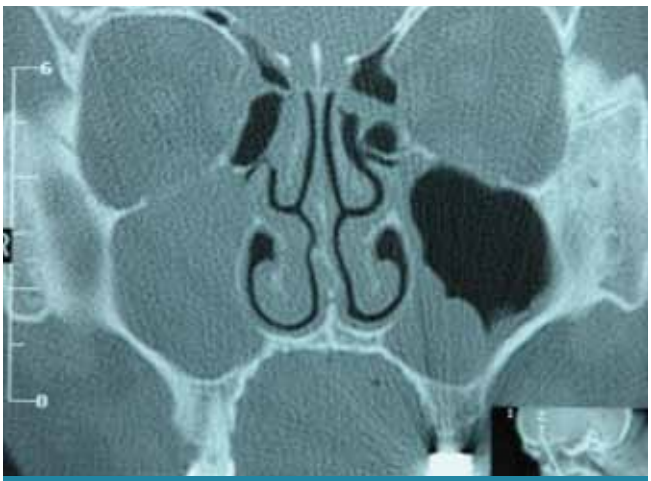
- Examine the nasal cavity prior to the operation
- Review the relevant anatomy for this procedure
- Compare and contrast the techniques used to perform an endoscopic sinus surgery
- Identify the surgical devices needed to perform sinus surgery
- Recognize the causes for concern following the operation



CT scan showing right opacified maxillary sinus with medial bulging causing expansion of the sinus and obstruction of the right nasal cavity.



Right maxillary mucocele eroding superior wall of the sinus causing eye proptosis and cheek swelling.



Right maxillary mucocele causing bulging of the uncinate process.

ANATOMY

Patients predisposed to developing chronic sinusitis may have anatomical deformities, nasal polyps, allergies, environmental factors, immunological abnormalities, or hormonal factors that cause nasal swelling. This results in retention of secretions of the nasal passages and an increased potential for sinus infections. Accordingly, the symptoms patients may experience includes headaches, facial pressure, pain, swelling or tenderness around the eyes, cheeks, nose, and/or forehead. Additional symptoms include nasal drainage that is yellow to green, nasal obstruction, decreased sense of smell and taste, cough, ear pain, halitosis, and fatigue.

It is important to understand the anatomy and functionality of the sinuses and surrounding structures in order to understand the surgical treatment options. The nasal cavity is divided midline by the nasal septum. The turbinate bones are layered one above the other, separated by grooves and superior, middle, and inferior meatuses aiding in drainage passages of the accessory sinuses. The nasal sinuses are comprised of the frontal, ethmoid, maxillary, and sphenoid sinus to serve as air spaces and conduits between the nasal cavities through meatuses. The frontal, anterior ethmoid, and maxillary sinus drain into the middle meatus. The posterior ethmoid and sphenoid drain into the superior meatus and sphenoethmoid recess. The sensory nerve supply originates in the trigeminal nerve, and the blood supply originates from the branches of the internal maxillary, anterior ethmoid, sphenopalatine, nasopalatine, pharyngeal, and posterior ethmoid arteries.[4] The veins are located in the epithelial layer of the turbinate bones.

ADVANCES IN IMAGING

In the doctors' office, the patient will be examined with a flexible endoscope under topical anesthesia. Computer axial tomography (CAT) scan of the sinus in a coronal plan may be ordered to reveal abnormalities. CT-MRI fusions offer optimal information for the clinician to make crucial surgical decisions. These CT-3D reconstructions and stereotactic navigations are bridged and used perioperatively during imaged-guided ESS to facilitate complicated procedures and will decrease the need for revision procedures.[2]

TREATMENT PRIOR TO SURGERY

The patient may often be treated by his or her doctor prior to surgery in a medical modality where they are given a course of antibiotics, nasal sprays, nasal rinses, and allergy testing. This course of treatment, though effective, may eventually result in surgical intervention when all other explored options do not eliminate the patient's symptoms.

SURGICAL TECHNIQUE

The patient is placed in the supine position with his/her arms usually tucked at his/her sides. The elbows should be protected to prevent ulnar nerve damage. The face and nose are prepped according to the surgeon's preference, and guidelines. A head drape is usually applied after general anesthesia is administered. The eyes may remain untaped, yet protected, in order for the surgeon to visualize and palpate during the procedure so the orbital area will not be damaged during the procedure.

The surgeon usually injects the nose with 1% lidocaine with 1:100,000 epinephrine to numb the nose and decrease bleeding due to the vasoconstriction effects of the medication. Topical solutions, such as 4% cocaine or 4% lidocaine, are placed on cottonoid patties and packed in the nose bilaterally to reduce the risk of any potential bleeding and provide anesthesia.

A full array of endoscopes should be available including but not limited to 4mm in diameter with 0-, 30-, 45-, and 70-degree viewing angles. A 2.7mm diameter scope with varying viewing angles also should be accessible. The varying angles will allow a surgeon to view all aspects of each sinus. The lens may be dipped in an antifog solution to clean and prevent fogging during insertion due to the change in temperature from room air to the nasal cavity. Sinus content that needs to be removed can be taken out by using an array of graspers and tru-cut forceps placing the removed tissue on a non-adherent surface or in saline. The specimen must be clearly labeled so as not to confuse each specimen for diagnosis purposes.

Periodically, cottonoids with topical epinephrine, cocaine, oxymetazoline hydrochloride, or lidocaine may be placed in the nose to control bleeding for better visualization and to minimize blood loss.

At the conclusion of the procedure, hemostatic agents may be placed in the nose to control bleeding postoperatively. Packing may be placed to physically apply pressure within the middle nasal meatus.

Surgical length can vary depending upon unilateral or bilateral pathology and surgeon specific techniques. Multiple sinuses may be affected which can increase the length of surgery.

Nasal polypectomy is the removal of polyps from the nasal cavity, which usually are comprised of benign grape-like clusters of mucous membrane and connective tissue.[4] The removal of nasal polyps will free the airway of the obstruction. This may be performed in conjunction with other sinus surgery or septal surgery.

Ethmoidectomies usually are performed to treat chronic sinusitis or polyps that are a result of allergies. This is executed by removing the middle turbinate, ethmoid cells, and diseased tissue to ensure better drainage and aeration of the ethmoid sinus.[4]

> ESS is the examination of the nasal cavities through an endoscope with the possible resection of inflamed nasal tissue and the correction of anatomical defects in the sinuses.

Turbinectomies, outfracture of the turbinates, turbinoplasties, or submucous resection of the turbinates can be performed during this procedure. A turbinectomy is the removal of a portion of the inferior and middle turbinate to increase aeration and drainage. Outfracture of the turbinates is the movement of the inferior turbinates to lateral nasal wall. This technique is minimally destructive.[1] Turbinoplasties are performed to shrink the size of the turbinates. This can be done by using a radiofrequency device. A submucous resection of the turbinates is when an incision is made intranasally through the mucous membrane to access the turbinate and remove a portion of it.

SURGICAL DEVICES

A microdebrider is a powered instrument that is used to shave out sinus contents. The blade consists of an inner-rotating blade within a fixed sheath with a sharp-edge window. This blade can either rotate or oscillate depending on

the result desired by the surgeon. The microdebrider is usually attached to irrigation and suction to aid in keeping the lumen of the instrument patent. The sinus contents are suctioned into a collection device where they can be collected, labeled, and sent to pathology for microscopic evaluation. Surgeons commonly use the microdebrider for soft tissue and polypoid tissue, but burrs can be used to open up the ostia, for extensive bony dissection of the sinuses.

By using a computer monitor, image guidance during sinus surgery allows the surgeon and surgical team to view the exact location of surgical instrumentation. This is especially useful during revision sinus surgery when landmarks in the nasal cavity are not evident, due to alterations during previous surgery. This requires the surgeon to acquire a specific CAT scan prior to surgery that can be utilized by the image-guidance device on the day of surgery.

Balloon sinuplasty is a minimally invasive procedure performed during sinus surgery where a small, flexible, sinus balloon catheter is gently guided into a sinus then inflated. This procedure restructures and widens the walls of the sinus cavity while maintaining the integrity of the sinus lining. Most commonly this can be performed on the frontal sinus, but can be utilized on all the nasal sinuses. The procedure involves inserting a sinus guide catheter into sinus ostia under endoscopic visualization or transillumination via an illuminating system. The balloon catheter is then threaded over the guide wire and inflated then deflated. An irrigation catheter also can be utilized to flush the sinus at completion of the balloon sinuplasty.

PREPARING THE OPERATING ROOM

The OR must be equipped with a video monitor display system, high definition camera, and light source placed opposite the surgeon. Any other devices such as microdebrider, cautery, suction, and other surgeon-specific devices should be placed toward the patient's feet. An imaged-guided machine is placed next to the video monitor in order for the surgeon to continuously check the placement of instrumentation. An additional Mayo stand may be draped and placed above the patient's head to place sterile equipment, but most importantly to support the surgeon's elbow that is holding the camera. Any foot pedals should be placed prior to the procedure to ensure correct placement where the surgeon will be standing during the procedure.

SURGICAL TECHNOLOGIST CONCERNS

The surgical technologist should use a Mayo stand to hold equipment that will be used during the procedure and a back table to encompass all additional trays of instruments. Basic nasal instruments should be available and endoscopic sinuscopes should be checked prior to surgery for clear visualization and functionality for optimal viewing. All equipment should be in optimal working condition and checked prior to the commencement of surgery. A separate preparation area may be a surgeon's preference where preoperative injection of local anesthesia and topical medications may be administered.

All specimens must be accurately checked for laterality for diagnostic purposes and should be handled according to the policy and procedures of the institution. If irrigation is utilized during the procedure, it is important to be aware of the amount in order to calculate accurate blood loss at the termination of the procedure.

POSTOPERATIVE CARE

The patient will leave the OR in the supine position with his/her head slightly elevated. The patient will be instructed to breathe through his or her mouth due to the swelling and possible packing that may be in the nasal cavity. The postanesthesia care unit (PACU) nurse will administer humidified oxygen and observe the patient for bleeding, pain, facial swelling or abnormal hypertension, level of consciousness or pupil dilatation.

Complications are uncommon yet range from synechia (a disease of the eye) or scar formation to cerebral spinal fluid leaks and orbital hematomas. Initially, slight oozing or bleeding may occur; however, any hemorrhage would need to be addressed with the surgeon immediately.

Balloon sinuplasty is a minimally invasive procedure performed during sinus surgery where a small, flexible, sinus balloon catheter is gently guided into a sinus then inflated.

The surgical technologist must be cognizant of sinus anatomy, be up-to-date with technology, and aware of surgical technique in order to perform as an integral part of the surgical team during an endoscopic sinus surgery. This can aid in decreased OR time for the patient and positive patient outcomes. Limited invasive surgeries are increasingly being performed in order to get patients out of the hospital quicker and back to normalcy sooner.

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Theresa Criscitelli, CST, RN, MS, CNOR, has been in the OR for 24 years and is a nurse educator at Winthrop University Hospital in Mineola, New York. She is also a clinical instructor of surgical technology at Nassau Community College in Garden City, New York. She obtained her Master's Degree in nursing education and is now pursuing a Doctorate of Education. Her clinical expertise is otolaryngology and educating staff and students.

OTHER APPROACHES TO SINUS SURGERY

Jodi B Farmer

Before more common procedures were developed, functional endoscopic sinus surgery was part of a surgical strategy that removed all the sinus mucosa from the major sinuses. The nasal endoscope was developed in the 1950s as a "natural pathways" approach. It was thought that the endoscope was the best way to obtain healthy sinuses. FESS includes the insertion of the endoscope, a thin fiber-optic tube, into the nose for examination of the sinus openings. The endoscope allows the surgeon to identify the abnormal and obstructive tissues and remove them. Most of the procedure is completed through the nostrils and usually leaves no external scaring. Common side effects include swelling and mild discomfort. The patient usually will have some nasal packing after the surgery. FESS is usually less extensive than other sinus surgeries and frequently can be performed on an outpatient basis.

Image-guided surgery allows a mapping system that features computed tomography (CT) scans and real-time information to show the surgeon the position of surgical instruments by using infrared signals. Typically, this technique is recommended for severe cases of chronic sinusitis. It may be recommended if the patient had previous sinus surgery that altered anatomical landmarks, or when a patient's sinus anatomy is unusual.

Since the sinuses are close to the brain, eyes and major arteries, there is major concern when tubes are inserted into this region. However due to advancing technology, image-guidance surgery is becoming very effective. The practice uses similar principles that the United States armed forces use to guide bombs to their target.

The Caldwell Luc operation relieves chronic sinusitis by improving the drainage of the maxillary sinus. The procedure is done by inserting tubing through the upper jaw above one of the second molar teeth. A window is created that connects the maxillary sinus with the nose. This action allows for an improvement in drainage. This procedure is often performed when a malignancy is present in the sinus cavity.

Sinus Surgery. American Academy of Otolaryngology – Head and Neck Surgery. ***http://www.entnet.org/HealthInformation/SinusSurgery.cfm.*** Accessed May 16, 2011.

U.S. Navy photo by Mass Communication Specialist Seaman Clay Whaley/Released

MCSLEEPY ADVANCES

Automated Anesthesia and Natural Orifice Transuluminal Endoscopic Surgery

by Douglas J Hughes, CST, CSFA, CSA, CRCST

As the world moves further into a future booming with technological advances and scientific discoveries, many aspects of society will be directly impacted and potentially enhanced in groundbreaking ways. Few areas or fields of practice have experienced these advancements with as much fervor as healthcare and medicine. Throughout the history of medical practice, technological advances have had dramatic impacts on such aspects as the delivery of care, the discovery of disease and the treatment of a myriad of conditions and illnesses. Today, several new technologies are emerging on the horizon and each carries the potential to fundamentally change modern healthcare and medical sciences yet again. Two specific examples of interest are automated, closed-loop anesthesia systems and natural orifice transluminal endoscopic surgery.

AUTOMATED, CLOSED-LOOP ANESTHESIA SYSTEMS: MCSLEEPY

More than 150 years ago, Boston dentist, William TG Morton, and renowned surgeon John Collins Warren, MD, worked together to pioneer and demonstrate the first-ever painless surgery using general anesthesia administered in the form of ether. After successfully removing a vascular tumor from the jaw of a patient named Gilbert Abbott at Massachusetts General Hospital in 1846, the two ushered in a new era in surgical medicine and laid the foundation for modern operative intervention aided by the administration of anesthetic agents.[9] Since that time, the use of general anesthe-

John Collins Warren, MD

William TG Morton

LEARNING OBJECTIVES

- Define natural orifice transluminal endoscopic surgery
- Examine automated, closed-loop anesthesia systems
- Explore McSleepy and the revolution of robotic systems in the operation room
- Examine how robotic systems will advance the future of surgical procedures
- Assess the current and future states of NOTES

Thomas M Hemmerling, MD, works with McSleepy, the first fully-automated anesthesia robot.

sia has become highly refined, sophisticated and routine. As researchers and practitioners alike continue to explore and implement safer and more efficient methods for administering and monitoring intraoperative anesthesia to control pain, induce muscle relaxation, and maintain patient hypnosis and unconsciousness, new advanced technologies are surfacing with increasing fervor.[8] Perhaps the most revolutionary advancement in modern anesthesia science since Morton and Warren successfully conquered operative pain is currently being trialed at McGill University Health Centre in Montreal, Canada. This new technological marvel, dubbed "McSleepy" by its creators, is a highly advanced, automated, robotic system capable of administering and maintaining anesthesia more safely and efficiently than a living, breathing anesthetist.[11]

ANESTHESIA MONITORING AND AUTOMATION

Since the early days of ether use, a fundamental problem related to the art of anesthesia delivery and maintenance has remained. Despite the many advances in intraoperative patient monitoring and the discovery of more sophisticated and safer drugs, there is still a great deal of subjectivity that exists in knowing when the correct amount of anesthetic agent has been given to the patient to produce the desired level of effectiveness while maintaining adequate homeostasis.[6] As early as the late 1940s and 1950s, experimenters such as Reginald Bickford, MD, used the electroencephalogram (EEG) — and recently the bispectral index (BIS) — as a method of monitoring the relationship between the amounts of anesthetic administered to the patient and the subsequent level of unconsciousness attained. The advent of such technologies made it possible for researchers and practitioners in anesthesiology to control at least one aspect of anesthetic drug administration and ultimately automate it in order to reduce the amount of subjectivity related to dosage and titration.[5,6] This type of automation was developed in the form of closed-loop anesthesia systems.

CLOSED-LOOP ANESTHESIA DELIVERY SYSTEMS

Closed-loop anesthesia systems utilize complex algorithms based on patient data such as BIS monitoring, initial drug dosage, pharmacokinetics, pharmacodynamics and other biological factors to calculate and administer the appropriate intraoperative anesthesia dosage for each surgical patient. Such systems have been known for the administration and dosage of intravenous propofol for several years, although their acceptance in the clinical setting has been slow to mature due to limited reliability and safety because of a lack of robust patient monitoring technology. Glass[5] referred to a study by Struys et al that noted that such systems, while still in their clinical infancy, showed great potential and provided better hemodynamic control and faster patient recovery under ideal conditions than manual administration of propofol via a human anesthetist alone. However, the variability in biology between patients and the difficulty in monitoring various physiologic and pharmacokinetic aspects of anesthesia during automated administration has limited the usefulness of such closed-loop systems until recently. Since these earlier studies only a decade ago, Glass[5] states that current technological advances in patient monitoring and algorithmic pharmacology have lead to better control over patient-specific biological factors and subsequently to the development of more robust closed-

loop systems capable of more comprehensive intraoperative duties. Although he contends that these systems have a long way to go before they replace human practitioners, the idea of clinically-viable automated anesthesia administration is no longer a matter of science fiction.[6,10] No better example of this exists today than the advances made at McGill University during the last couple of years.

MCSLEEPY: THE FIRST FULLY-AUTOMATED ANESTHESIA ROBOT

In early 2008, the world's first fully-automated anesthesia system — McSleepy — was successfully tested during a 3½-hour partial nephrectomy procedure at McGill University Health Centre in Montreal. Using advanced closed-loop anesthesia technology and highly sophisticated patient monitoring techniques and algorithms, McSleepy is capable of performing anesthesia administration and maintenance for an entire surgical procedure with limited human oversight.[13] When describing the technology, Thomas M Hemmerling, MD, the lead researcher for the project, stated, "Think of McSleepy as a sort of humanoid anesthesiologist that thinks like an anesthesiologist, analyses biological information and constantly adapts its own behavior, even recognizing monitoring malfunction."[11]

Commonly referred to as an anesthesia robot, McSleepy monitors the patient's level of consciousness, pain and muscle movement throughout the course of the surgery and adjusts the level and dosage of intravenous agents accordingly. In order to facilitate its operation, the patient is connected to several advanced biological sensors and demographic information such as age, weight, height, sex and type of surgery to be performed is entered into the system. McSleepy also has the ability to store and learn surgeon and anesthesiologist-specific preferences through incorporated artificial intelligence technology. Every minute that the patient is under general anesthesia, McSleepy uses the mathematical algorithms of its closed-loop programming, via LabView-developed software, to monitor and dose the anesthetic agents. As a fail-safe in the event that McSleepy malfunctions, anesthesia providers are able to override the system and revert to manual control of anesthesia administration. The override feature also gives them the ability to alter doses as needed based on their individual preferences and observations.[8]

BENEFITS AND POTENTIAL IMPACT

In October 2010, the McSleepy anesthesia robot was combined with the DaVinci surgical robot to perform the world's first total-robotic operation. Utilizing these two systems together to perform a successful prostatectomy procedure on a MUHC patient, the event has begun a new chapter in the quest for less invasive, faster, safer and more accurate surgical interventions. Although researchers contend that some work still needs to be done to perfect the approach, there is little doubt that all-robotic surgical techniques will gain interest and eventual acceptance. In light of the recent press — and because the use of McSleepy has been shown by McGill researchers to lead to higher quality patient care, better intraoperative monitoring, and more accurate dosing and maintenance of anesthesia by eliminating the subjectivity of human clinicians — it is likely that the technology will stay.[12]

Along with the major benefits associated with advanced patient monitoring and more accurate dosing, several other advantages to using McSleepy in the clinical setting exist, thus lending it the potential to revolutionize patient care. The most obvious added advantage is the fact that using this system will free anesthesiologists from the time-consuming burden of monitoring, and managing the administration of intraoperative agents. According to Hemmerling,[8] anesthesia providers spend approximately 20% of their time engaged in these activities. Thus, they will be able to focus their time and energy on other important aspects of patient care. The decreased oversight may also lead to a 20% to 25% drop in total costs for anesthesia services, therefore making surgery more affordable to patients.[3]

Unlike other prototypes, McSleepy's program is loaded onto a laptop connected to monitors and infusion pumps and sports a user-friendly interface that is similar to that of current anesthesia delivery systems. This feature has led to a great deal of interest among clinicians as other concepts under development lack such an interface and are harder to program and use.[8,11] Because of this advantage, Hemmerling

"Think of McSleepy as a sort of humanoid anesthesiologist that thinks like an anesthesiologist, analyses biological information and constantly adapts its own behavior, even recognizing monitoring malfunction."

believes that patients will be less reluctant to rely on the system because it is more "visible" and reduces the fear of an unknown device or "black box" taking over.[11,13]

Minimally-invasive approaches to operative access and exposure have served to greatly reduce the risks and complications associated with the creation of larger, more complicated wounds.

Another important advantage of McSleepy is its integration of Wi-Fi and mobile technology. The system gives the operator the ability to monitor the patient's progress and drug dosages from any location via a PDA.[3] The implications of this feature may prove to be astounding. Essentially, clinicians will be able to monitor several patients simultaneously via a remote or centralized location. All of the functions available through McSleepy's laptop interface are also accessible wirelessly. In the future, this may prove to be highly beneficial in countries that lack access to skilled anesthetists.[8]

THE FUTURE

Although Hemmerling recognizes that many patients initially will be skeptical of this new technology and prefer a human anesthesiologist at their side, he has been bold enough to state that McSleepy will enter the US market within the next five years. His team is currently preparing commercial versions of the automated anesthesia system and is actively involved in the approval process through both the US Food and Drug Administration and Canadian health agencies.[8] With clinical evidence showing that automated systems may in fact be better and more efficient than manual anesthesia administration alone — and considering the recent advances in patient monitoring paving the way for more viable closed-loop algorithmic anesthesia systems — Hemmerling is not alone in his optimism. Glass[6] stated, "I remain optimistic that closed-loop control of anesthesia ultimately will prove to be superior and will become routine in providing anesthesia." Although devices such as McSleepy and other surgical robots such as DaVinci stimulate the thought of replacing doctors with machines in the not-too-distant future, Hemmerling contends that, "Robots will not replace doctors, but help them to perform to the highest standards."[18] While this may be true for now, a future in which patients are routinely cared for and treated by robotic physicians is certainly on the horizon.

NATURAL ORIFICE TRANSLUMINAL ENDOSCOPIC SURGERY

Throughout the history of surgical intervention, practitioners have continuously sought methods to achieve their desired operative outcomes while minimizing specific negative side effects such as large incisions, postoperative pain, lengthy recoveries and the risk of wound infection, to name a few. During the last two centuries, the advent of endoscopes and related technologies has played a central role in the genesis of modern therapeutic and diagnostic techniques. From Phillip Bozzini's development of the first crude endoscope in 1805, to the development of the first technique for laparoscopic removal of the gallbladder by the German surgeon Erich Mühe in 1985, the evolution of minimally-invasive methodologies has been dramatic and revolutionary.[20] Following this tradition, a new experimental approach, known as natural orifice transluminal endoscopic surgery, or NOTES, shows great potential to further alter the state of disease diagnosis and treatment in a fundamental way.

BENEFITS OF MINIMALLY-INVASIVE SURGERY

One of the most obvious commonalities shared by operative procedures across the various disciplines is the creation of the surgical wound or incision to gain access to and expose the operative field. Traditionally, such incisions have been performed through normal, intact, external structures such as the pelvis, flank and abdomen. As incisions are carried through superficial and deeper tissues such as the skin, subcutaneous fat, fascial layers, various musculatures and the peritoneum, the disruption of complex anatomic structures and physiologic systems is an inherent consequence. Therefore, the patient is subjected to complications in the form of postoperative pain, scarring, possible wound infection, incisional hernia and others.[16] Minimally-invasive approaches to operative access and exposure have served to greatly reduce the risks and complications associated with the creation of larger, more complicated wounds.[2] The current minimally-invasive laparoscopic revolution has greatly enhanced recovery of the surgical patient while simultaneously decreasing morbidity, postoperative pain, healing time, length of hospital stay and certain risks such as intestinal ileus and tissue adhesions when compared to

traditional open laparotomy approaches. Also, the smaller incisions employed during laparoscopic techniques results in enhanced cosmesis and greater patient satisfaction.[1] Yet despite these numerous benefits, researchers and clinicians still are actively seeking further improvements. There are a growing number of surgeons who are looking for ways to not only minimize the size of incisions into the skin, but eliminate them altogether. Therefore, the recent developments in natural orifice transluminal endoscopic surgery offer the next potential revolution in minimally-invasive operative techniques.[19]

NOTES DEFINED

Reaching beyond the capabilities of even the most advanced laparoscopic systems available on the market today, NOTES utilizes the body's natural orifices to access internal abdominal organs and structures without leaving an external scar. The insertion of a highly sophisticated endoscope and advanced surgical instrumentation into external structures such as the mouth, urethra, anus or vagina will enable surgeons to perform operative procedures without the need to create even the smallest incision into the abdominal wall. The natural orifice approach holds tremendous potential to reduce patient complications and improve postoperative recovery time as the risks and side effects associated with abdominal incisions are completely eliminated.[2]

THE PROCEDURE

According to Yan and Thompson-Fawcett,[20] five approaches to NOTES peritoneal access have been identified. They include are transcolonic, transgastric, transvaginal, transvesical and a combined method. Selecting the desired point of entry into the body will depend largely on the area of the abdomen to be accessed as each route provides for visualization of different internal organs and separate portions of the abdominal cavity. In either of these approaches, the procedure involves the insertion of an endoscope through an overtube into the chosen orifice followed by the thorough suctioning of its contents and an antibiotic lavage. Additionally, bowel prep, water enemas, aggressive intraluminal washing and an external skin preparation with povidone iodine scrub solution may be necessary for transcolonic procedures. The endoscope used to prepare the operative site for the incision is then removed to reduce the presence of microbial flora, and another — with additional working channels — is introduced. A small viscerotomy or enterotomy is then created in the wall of the viscera or intestinal tract with a small instrument such as a 4-mm needle-knife delivered via the endoscope. The incision can then be enlarged using any of several different endoscopic instruments depending on the surgeon's preference. Commonly, a 1.5-cm pull-type sphincterotome, or balloon dilator is employed for expansion. Once this step is complete, the endoscope is advanced through the incision and into the peritoneal cavity, where the surgical intervention will take place.[14,19,20] Pneumoperitoneum is then achieved with carbon dioxide gas at an intraabdominal pressure not to exceed 15 mmHg.[20] Using standard endoscopic instrumentation, a number of surgical procedures can be performed. Once the procedure is complete, the viscerotomy is tightly closed using endoclips or a prototype closure device to prevent spillage of the visceral contents into the abdomen. Finally, the endoscope, surgical instrumentation and overtube are removed from the body orifice.[19]

An endoscopic surgery operation room.

THE CURRENT STATE OF NOTES RESEARCH

Following these basic operative steps, researchers have been able to trial the effectiveness of NOTES in a variety of surgical cases ranging from peritoneal endoscopy, to transvaginal cholecystectomy, to transgastric gastrojejunostomy and splenectomy.[19] This new "scarless" approach to operative and diagnostic therapy is a combination of both endoscopic and laparoscopic techniques and is currently in its experimental/developmental phase.[14] Much of the research has been conducted using animals such as canine and porcine models since Kalloo et al performed the first transgastric peritoneal exploration on a pig in 2004.[20] However, human trials have been conducted to a minimal extent and largely have been confined to transgastric appendectomies performed in Hyderabad, India, by GV Rao, MD, and Nageshwar Reddy, MD.[19] Data related to these human trials of NOTES technology are limited at best. The tremendous interest in this tech-

nology also has led to the performance of several hundred hybrid laparoscopic assisted NOTES procedures in Asia and the US, most commonly transvaginal procedures.[1] Overall, these cases have proven to be highly successful demonstrations of the potential for natural orifice surgery to revolutionize modern medicine and surgical practice.

CURRENT LIMITATIONS AND CHALLENGES

Although the operative procedure may seem straight forward, several limitations and challenges must be overcome before NOTES can be defused into mainstream surgical practice. The biggest hurdle in the way of this technology is the current lack of an effective closure device for the internal wall of the viscera. Many practitioners and researchers have opted to use endoclips for viscerotomy and enterotomy wound closure. However, these devices are intended for the maintenance of intraoperative hemostasis and are not adequate for primary tissue approximation as they are incapable of full-thickness tissue closure. Currently, devices are being prototyped to meet this emerging need.[19]

Another one of the critical drawbacks at this stage of development is the lack of adequate surgical instrumentation and equipment needed to facilitate fully transluminal procedures on human patients. Although many successful procedures have been performed on animal test subjects, human anatomical structure and tissue vary greatly from these species. Attaining the high level of clinical precision that is necessary to manipulate human tissue is not currently possible without more specialized endoscopic instruments.[2] Standard endoscopic instrumentation such as graspers, baskets, forceps, electrosurgical devices and scopes lack the flexibility requirements and degrees of freedom needed to carry out a safe and efficient NOTES operation.[1] Furthermore, several advances are needed to improve the field of visualization and overall functionality available in flexible endoscope models on the market.

The concept of natural orifice transluminal endoscopic surgery promises to completely revolutionize modern surgical medicine by overcoming the many drawbacks that exist with current operational methods.

Currently, several companies are designing and testing prototype endoscopes, closure devices and endoscopic instrumentation to meet the specific demands of NOTES procedures. A myriad of new technological advances will reach the market during the next few years, effectively bridging the gap that exists between theory and practice.[1,7] In the meantime, natural orifice transluminal endoscopic surgery will have limited benefit to humans. However, experimentation with hybrid surgical approaches and research through animal trials will most certainly continue.

THE FUTURE

The concept of natural orifice transluminal endoscopic surgery promises to completely revolutionize modern surgical medicine by overcoming the many drawbacks that exist with current operational methods. As new NOTES technologies are developed and defused into practice, Forgione[4] contends that they will, "Lead to the design of completely new interventional procedures, and change the way we will operate, bringing us to the previously unimaginable goal of 'no-scar surgery.'"

Just what exactly will the future of NOTES look like? For one, the elimination of the abdominal incision and use of minimally-invasive endoscopic technology will allow needed procedures to be performed on patients that are not currently considered viable surgical candidates, such as ICU patients suffering from comorbid diseases, other illnesses or conditions and advanced age. The portability of this technology will even enable such procedures to be performed bedside in ICU and emergency department suites.[15] This factor alone carries the capacity to fundamentally change surgical principles and practices in a profound way. Also, substantial decreases in tissue trauma, operative pain, the time needed for dissection and exposure of the operative field, as well as the elimination of the need for abdominal muscle paralysis, will likely allow many NOTES procedures to be performed under conscious sedation rather than general anesthesia.[14,15] This advantage will greatly decrease postoperative recovery time and the risk of anesthetic complications. Furthermore, the fact that endoscope reprocessing utilizes high-level disinfection versus sterilization could make NOTES procedures appropriate for environments such as third-world countries and battlefields.[20] With all of these potential benefits, Song, Itawi, and Saber[17] believe that NOTES will soon make its debut in hospitals and spe-

cialty centers in the US. As the diffusion of this technology becomes a reality during the next decade, Chaudhry and Agrawal[2] point out that many levels of society will be directly impacted; specifically, hospitals and surgical centers, healthcare and insurance systems, government and legislative organizations and professional associations.

CONCLUSION

Automated, closed-loop anesthesia systems and natural orifice transluminal endoscopic surgery are two quickly emerging technologies that likely will have a drastic impact on healthcare and medical/surgical sciences during the next five to 10 years. Although currently under development, both are being evaluated as viable and effective alternatives to modern systems and techniques. These futuristic advancements already have sparked worldwide interest and promise to revolutionize both the healthcare industry and society alike.

ABOUT THE AUTHOR

Douglas J. Hughes is a surgical technology instructor at San Joaquin Valley College in Fresno, California. He graduated from Boise State University in 2009 with a Bachelor of Applied Science degree with emphasis in Surgical Technology from Boise State University and is now an honors student in the Master of Arts in Education program at California State University, Fresno. Since 2006, he has worked in the operating room in several capacities, first as a sterile processing technician and instrumentation specialist and, most recently, as a first assistant in orthopedic surgery. Doug also serves the profession as the vice president of the Association of Surgical Assistants and is the administrator and webmaster of Surgical Assistant Resource.

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Minimally Invasive POSTERIOR SPINAL FUSION

by Richard L Demko, CST

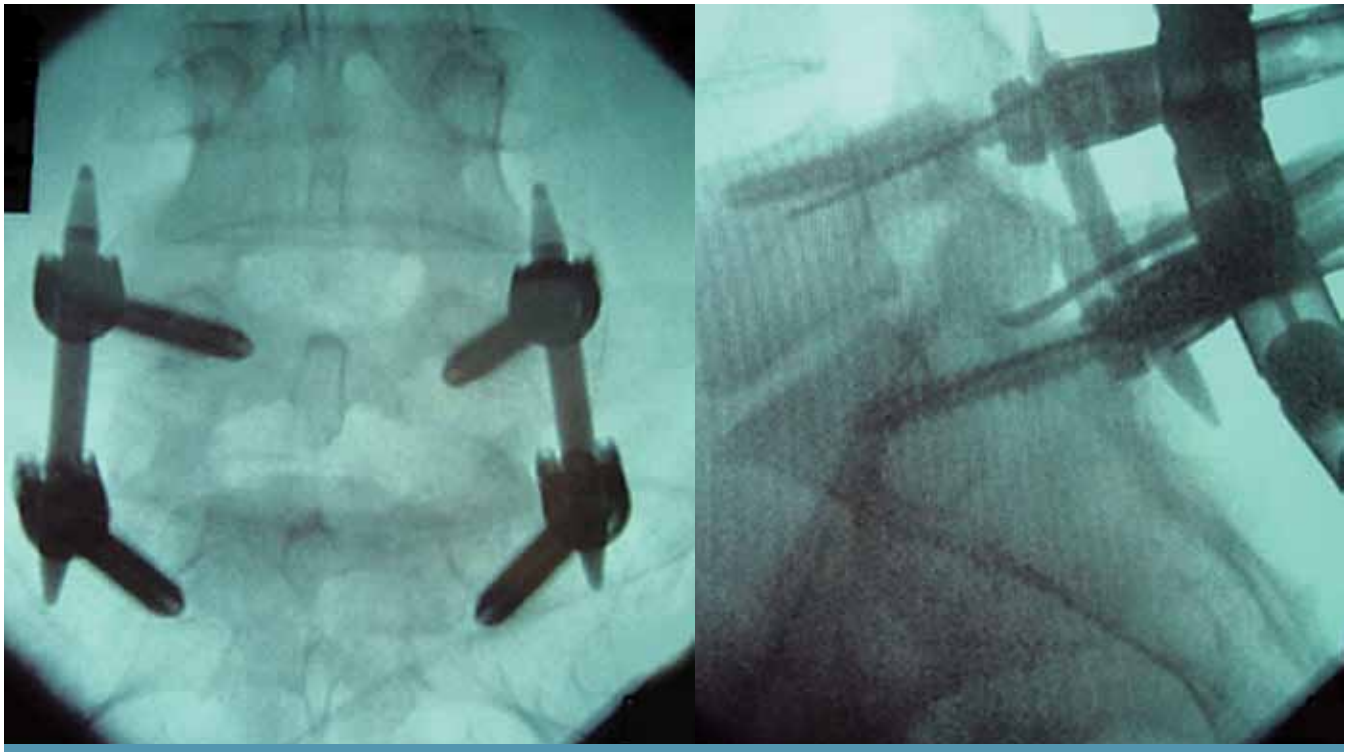
The CD Horizon® Sextant™ procedure is a relatively new advancement in the treatment of degenerative disc disease and other spinal instabilities. When used along with the CD Horizon® Minimal Exposure Tubular Retractor system (METRIx™), it gives the option to use the incisional technique by reducing the amount of dissection and exposure needed to perform a traditional spinal fusion. Unlike the open, invasive approach that requires a 6- to 8-inch incision and extensive exposure, this minimally invasive approach only requires 18mm stab incisions and gradual soft tissue and muscle dilatation to access the spine and its related structures.[2] The cosmetic outcome is similar to that of a laparoscopy, and the patient's postoperative pain, recovery time and hospital stay is greatly reduced.

HISTORY OF THE SEXTANT™ & METRIX™ TECHNIQUE

The Sextant™ procedure was developed in 2000 by neurosurgeon Kevin Foley, MD, at Methodist University Hospital, in Memphis, Tennessee.[1] The procedure was developed to facilitate the percutaneous placement of pedicle screws and stabilization rods under fluoroscopic imaging. The Minimal Exposure Tubular Retractor (METRIx™) system was developed in 1995 by Gary K Michelson, MD[3], and allows surgeons to perform a microdiscectomy, decompressive laminectomy and intervertebral body fusion using an operative microscope or high powered loupes through bilateral 12 to 18mm ports. By combining the two technologies, it gave birth to a completely minimally invasive procedure and opened new doors into the future of posterior lumbar spinal fusions.

LEARNING OBJECTIVES

- Examine how this minimally invasive procedure reduces recovery time and postoperative pain
- Analyze how the decompressive laminectomy is performed
- Learn what instruments and equipment are necessary for minimally invasive posterior spinal fusion
- List the complications associated with this surgery
- Assess the future of posterior lumbar spinal fusions



AP Lateral C-Arm Retractor Post

Photo Courtesy of John Awad, MD

CANDIDATES FOR THE MINIMALLY INVASIVE PROCEDURE

The most common indication for the minimally invasive procedure is severe disc degeneration. Other indications include recurrent disc herniation, spondylolisthesis (misaligned vertebrae) or traumatic fracture. The procedure is indicated for patients that require single to multi-level fusions.[2]

INSTRUMENTATION AND EQUIPMENT

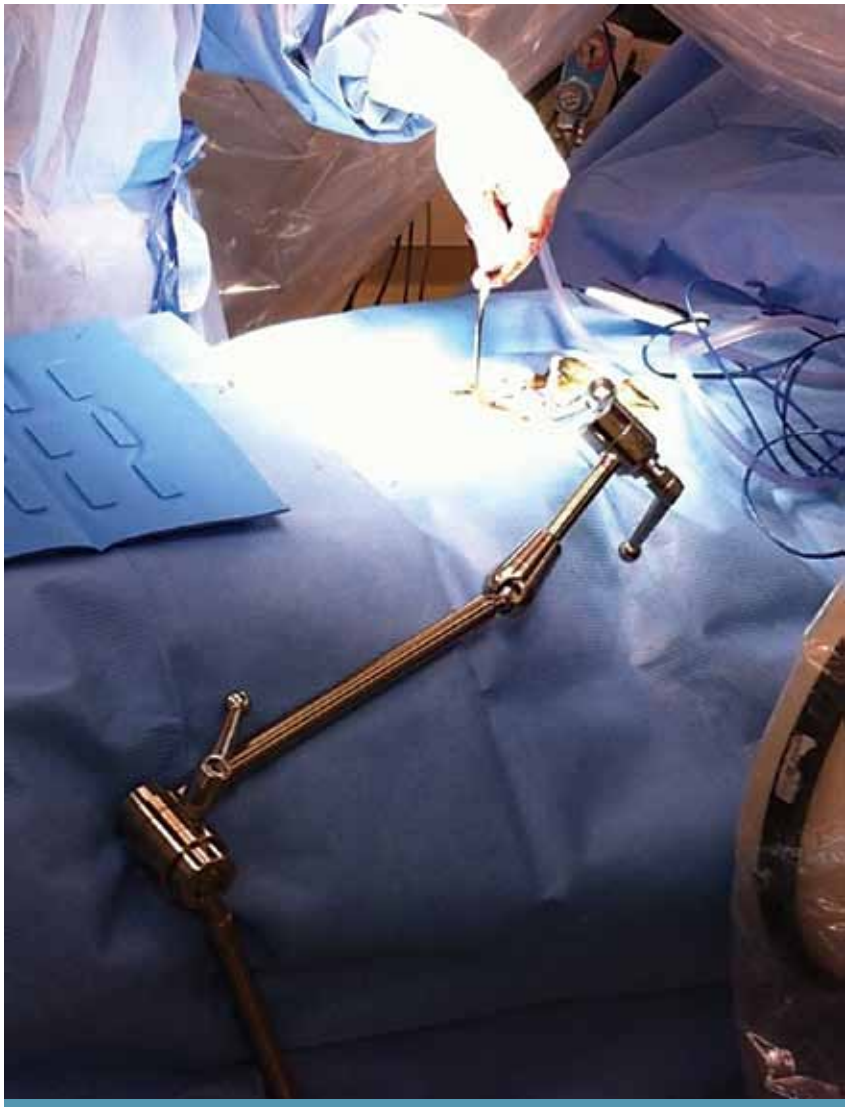
The set contains pedicle screws ranging from 4.5mm to as wide as 8.5mm diameter that attach to threaded, cannulated screwdrivers. Screw lengths range from 30mm to 60mm increasing in increments of 5mm. The screwdrivers double as a compressor/distracter and rod reducer allowing the placement of the stabilization rods with the rod introducer. The set also contains locking caps to keep the rod affixed to the pedicle screw. Included in the set are various diameter dilation tubes that spread the tissue to create a working channel down to the lamina. Most surgeons prefer to insert the MAST Quadrant™ retractor after dilation to allow for a larger field of vision. The retractor attaches to the Jackson table using a table post connected to an adjustable arm. A disposable light ring to facilitate better viewing in the wound attaches to the retractor, thus a light source and light cable is required. The working instruments are similar to traditional spinal fusion instruments with the exception that they are longer and bayoneted to allow easier access to and visualization of the spine through the dilation tubes or retractor system. Since the procedure requires anterior, posterior and lateral imaging, two fluoroscopy machines are needed along with lead X-ray aprons and thyroid shields.

The working instruments are similar to traditional spinal fusion instruments with the exception that they are longer and bayoneted to allow easier access to and visualization of the spine through the dilation tubes or retractor system.

Some surgeons prefer to use an operating microscope instead of loupes. The standard electrosurgery and bipolar machines also are needed. Based on the surgeon's preference, a nitrogen-powered high-speed burr may be required.

PATIENT PREP AND POSITIONING

The patient is transported in to the operating room on a gurney and the first part of the World Health Organization (WHO) safety checklist is performed by the surgical team. Once the correct patient, surgical site, allergies and procedure are verified, the patient is anesthetized on the gurney in the supine position. When induction is complete, a Foley catheter is inserted. After catheterization, the neuro-monitoring technician inserts electrodes into various nerves and muscles of the arms and legs to monitor the neurological function of the patient during the procedure. The neuro-monitoring technician establishes a baseline electromyogram and the patient is ready to be positioned. With the help of the OR staff, the patient is placed on the Jackson table in the prone position. The hips, knees, chest and any other bony prominences are padded to prevent pressure ulcers. Any hair around the operative site is removed. Both fluoroscopy machines are set up at this time. The first machine images the lateral lumbar spine and the second machine images the anterior/posterior lumbar spine. The fluoroscopy machines are positioned and scout images of the spine are taken to verify their levels before operation. Once the levels are verified, the surgeon marks the skin where the pedicles are located. The patient is then ready to be prepped and draped. The skin prep is performed in a customary manner using a prep solution of the surgeons' choice. The surgical team is gowned and gloved and the drapes are applied. This is done using four square towels, a ¾ sheet and a long transverse laparotomy drape. The electrosurgical pencil cord, bipolar cord, light cable and suction tubings are handed off the field for the circulator to hook up. Both C-arms of the imaging machines are draped with full C-arm drapes and the time out is performed along with the second part of the WHO safety checklist. The field is now set for the start of the procedure.



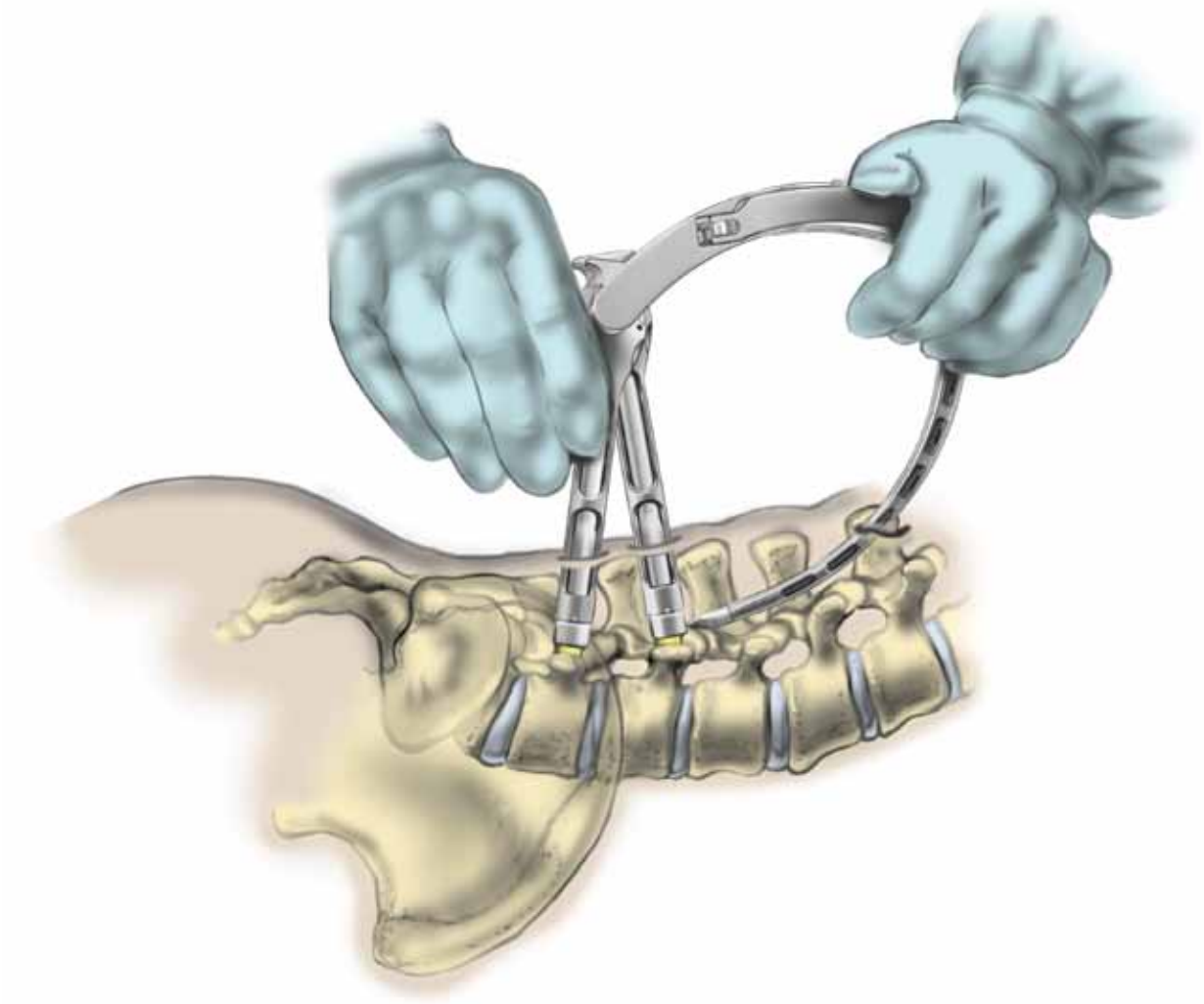
The MAST Quadrant Retractor table post

Photo Courtesy of John Awad, MD

PROCEDURE

(Since the minimally invasive procedure is indicated for single and multi-level lumbar fusions, a single level fusion of L3-L4 will be used as the focus of study for the procedural part of this article).

The surgeon injects 1% lidocaine with epinephrine 1:200,000 into the skin and subcutaneous tissues above the left and right L3-L4 pedicles to provide hemostasis. Using an 11 blade, a stab incision is made into the skin and the soft tissue is dissected using a tonsil clamp. A threaded guidewire is manually inserted into the pedicle using fluoroscopic guidance. Once the guidewire is in place, the sur-



The Sextant™ Rod Introducer

Photo Courtesy of Medtronic®

geon inserts a series of muscle-splitting dilators to create a wider field of view down to the pedicle. The incision is retracted using a tubular sheath to create the working port. Once the tissues are dilated and retracted, a sharp, cannulated tap is placed over the guidewire to prepare the pedicle for screw insertion. Using a long ball probe, the surgeon checks the hole that was taped to ensure that the lateral wall of the pedicle is still intact. A measurement is taken from the ball probe to determine the length of the screw needed. The surgical technologist loads the appropriate length screw on the threaded screwdriver and hands it to the surgeon for insertion. With the screw in place, a neurostimulator probe is used to check that the nerve root was undisturbed. The surgeon repeats the percutaneous screw insertion process for the remaining three pedicles. The surgeon removes the guidewires, but leaves the cannulated screwdrivers in place, which are attached to the screws, so they can be used to introduce the rod and distract the disc space later in the procedure. With all the pedicle screws in place, the next step is to perform a decompressive laminectomy. A stab incision is made in the skin 5mm off the midline on the left side of the spine. The soft tissue is dissected with a tonsil clamp. A threaded guidewire is inserted and advanced down to the edge of the lamina under fluoroscopic imaging. Once the guidewire is in place, the surgeon inserts the muscle-splitting dilators to create a working port down to

The discectomy will start on the side that is giving the patient the most pain, and will be done through the existing working port used for the laminectomy.

the lamina. If the MAST Quadrant™ retractor is used, the surgeon inserts the retractor blades and affixes them to an adjustable arm connected to a table post. The table post is attached to the Jackson table with the help of the circulator. With the retractor in place, the surgeon may wish to use the disposable light ring to enhance visualization of the spine. Using an angled curette, the surgeon removes small portions of bone from the lamina to gain entrance to the spinal canal. Once the spinal canal is reached with the curette, a 2mm Kerrison rongeur is used to remove the lamina that is compressing the spinal cord and nerve root. Using various dissectors, the surgeon probes the edge of the lamina to check for bone fragments and osteophytes. If found, these are removed using a 3mm or 4mm Kerrison rongeur and/or a high speed cutting burr. The surgeon is careful not to disrupt the nerve root during this process.

When the laminectomy is complete on the left side of the spine, the process is repeated on the right side. Once the spinal cord is decompressed, the surgeon prepares to insert the rods using the rod introducer. Using a caliper that attaches to the retained screwdrivers, the distance between the L3 and L4 pedicle is measured and the proper rod length is selected. The surgical technologist then loads a sharp cutting trocar to the rod introducer. The introducer is attached to the screwdrivers and a stab incision is made at the entry point of the skin where the trocar will be pushed through. The surgeon advances the trocar through the tissues to create a path for the rod. The trocar is then removed from the inserter and the proper length rod is attached. The rod is advanced through the tissues and is positioned between the pedicle screws until the rod is properly seated. When satisfied with the placement of the rod, the surgeon and assistant distract the disc space by pulling the two screwdrivers apart. Locking caps are advanced down the cannula of the screwdriver and are placed on the pedicle screws to secure the rod. This process is repeated for the right side L3 and L4 screws. By distracting the pedicles, it allows the surgeon to access the disc space to remove the degenerative disc and insert an intervertebral body cage or bone graft. Before starting the discectomy, an anterior/posterior and lateral fluoroscopic image is taken to ensure the proper placement of the pedicle screws and to verify that the rod is seated in the saddle of the screw with the locking caps firmly attached. The discectomy will start on the side that is giving the patient the most pain, and will be done through the existing working port used for the laminectomy. A suction nerve root retractor is inserted into the spinal canal

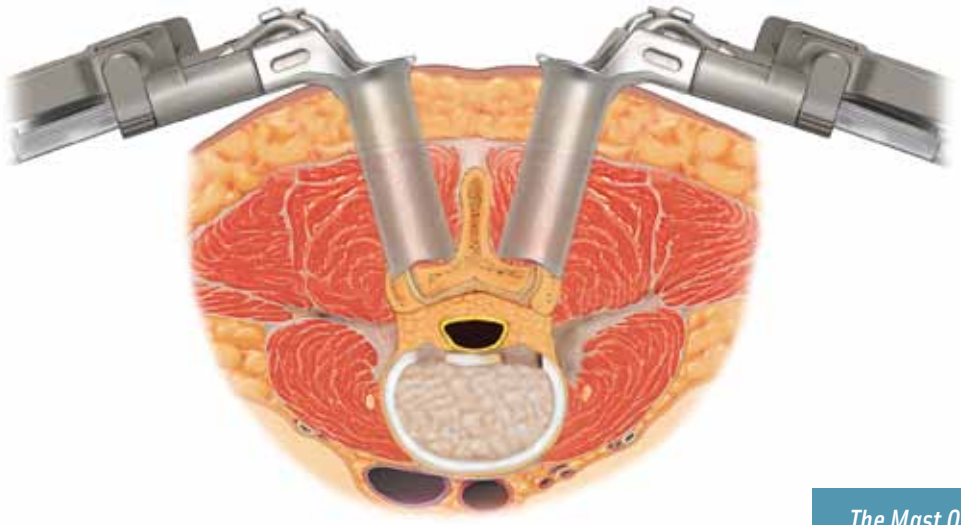


Photo Courtesy of Medtronic®

The Mast Quadrant™ Retractor

Within 3 to 4 hours after the procedure, the patient is encouraged to ambulate to aid in the recovery process. Typically with an uneventful procedure, the patient can return home within 24 to 48 hours and can resume normal activity within 3 days of discharge.[2]

to gently retract the spinal cord and allow the surgeon to visualize the disc. Using an 11 blade knife on a bayoneted handle, the surgeon makes an incision into the annulus of the disc. Using various serrated curettes and pituitary rongeurs, the disc is removed. To determine the size of the graft needed to replace the disc, the surgeon inserts a series of trials until the trial sits snug between the top and bottom vertebral end plates. The graft is introduced to the field by the circulator and the surgical technologist loads the graft on the inserter. Some surgeons prefer to place a synthetic bone substitute in the center of the graft prior to insertion to assist in the intervertebral body fusion. Using a mallet, the graft is taped in place and advanced down the disc space using a graft impacter. After the graft is in place, the locking caps keeping the disc space distracted on the rods are loosened, and the surgeon and assistant pull the screwdrivers together. This is done to compress the disc space and keep the graft in place. Once compressed, the locking caps are tightened and a final torque driver is used to ensure the rods are secured to the pedicle screws. The surgeon will then insert a mixture of an osteogenerative protein and bone chips along the lateral gutters of the posterior spinous process. This is done so the patient will generate bone growth aiding in the fusion of the two vertebral bodies. Prior to removing the retractors and screwdrivers, the neuro-stimulator is again introduced into the incisions to verify that the nerve roots and spinal cord were not compromised during the procedure. Final fluoroscopic images are taken to verify the screws, rods and intervertebral grafts are properly in place.

CLOSURE

The surgical technologist and circulator perform a sponge, needle and cotton patty count. Instruments are counted based on the hospital's policy for percutaneous cases. Once the counts are correct, the retractors and screwdrivers are removed from the wound. The wound is closed with interrupted 0 polyglactin suture on a tapered needle to approximate the deep layers of tissue. The superficial layers are closed with interrupted 2-0 polyglactin suture also on a tapered needle. The subcutaneous tissue is closed with running 4-0 polyglactin on a cutting needle and the skin is approximated using either wound closure strips or a tissue adhesive. Some surgeons prefer to close the skin with a 4-0 nylon suture. If this is to be done, generally the 4-0 polyglactin subcutaneous stitch is omitted. The dressings generally consist of small adhesive bandages. When the closure is complete and the final sponge, needle and cotton patty count are done, the third part of the WHO checklist is completed. The OR staff then returns the patient to the gurney from the Jackson table and the neuro-monitoring leads are removed. The patient is then extubated and transported to the Post Anesthesia Care Unit (PACU).

RECOVERY

The patient will spend a few hours in the PACU before being transported to the surgical floor of the hospital. Within 3 to 4 hours after the procedure, the patient is encouraged to ambulate to aid in the recovery process. Typically with an uneventful procedure, the patient can return home within 24 to 48 hours and can resume normal activity within 3 days of discharge.[2]

There are several complications that may occur to lengthen the patient's hospital stay. The most common complication of minimally invasive spinal fusions is a dural tear caused during the decompressive laminectomy. Most dural tears can be repaired through the working port, but in some cases the surgeon may have to convert to an open procedure to repair the defect. In this event the patient will spend more time in recovery, and will not be able to immediately return to normal activity. Other complications can include breaches in the pedicle wall, causing the screw to disrupt the spinal cord and/or nerve root; misplacement of the pedicle screw, causing instability of the fusion; hematomas; paralysis; foot drop; and surgical site infection.[4]

CONCLUSION

With the breakthrough of this minimally invasive technique, patients can return to an active life style within a fraction of the amount of time it takes one to recover from a traditional open spinal fusion. Blood loss is minimal, muscle and tissue is preserved causing less postoperative pain, time spent in the hospital recovering is significantly reduced and the improved cosmetic outcome make this minimally invasive approach more attractive to patients who are candidates for a spinal fusion.

ABOUT THE AUTHOR

Richard L. Demko, CST, graduated from the surgical technology program at Bridgeport Hospital School of Nursing, in Bridgeport, Connecticut. He completed his clinical rotation at Yale New Haven Hospital where his primary focus was in neuro-spinal and neuro-cranial procedures. He is an active member of AST and the Connecticut General Assembly of Surgical Technologists. Richard was recently elected to the Connecticut AST Board of Directors and serves as the chairman of the Government Affairs Committee. He is currently working at Saint Vincent's Medical Center and serves as a section leader for the spinal surgery service.

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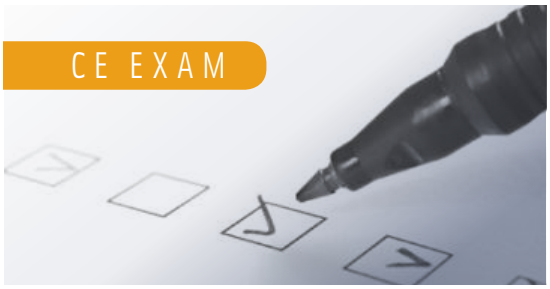

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EXPLORING THE

Penile Prosthesis Procedure

by Debbie Gutierrez, CST

Insertion of a penile implant is often performed in men with erectile dysfunction. This surgery is performed when prescribed medications or penis pumps do not work for the patient.[1] There are different types of implants used for this type of surgery. The two most popular types of implants are the inflatable implant and the semi-rigid implant. This procedure usually takes one to two hours and the patient usually is discharged the same day as the surgery.[8]

In this particular case study, the patient is a 60-year-old male who was scheduled to have outpatient surgery for the insertion of a semi-rigid prosthesis or implant. The patient's height was six feet, three inches and weighed 180 pounds. The patient's vital signs were taken preoperatively by the nurse: his blood pressure was 120/71; his heart rate was 83 beats per minute; his respirations were 18 breaths per minute; his oxygen saturation was at 96%; and his temperature was 36 degrees Celsius. His total Braden score was 23. The patient's NPO status also was checked prior to surgery. He was NPO for 12 hours upon his arrival to the hospital.[11]

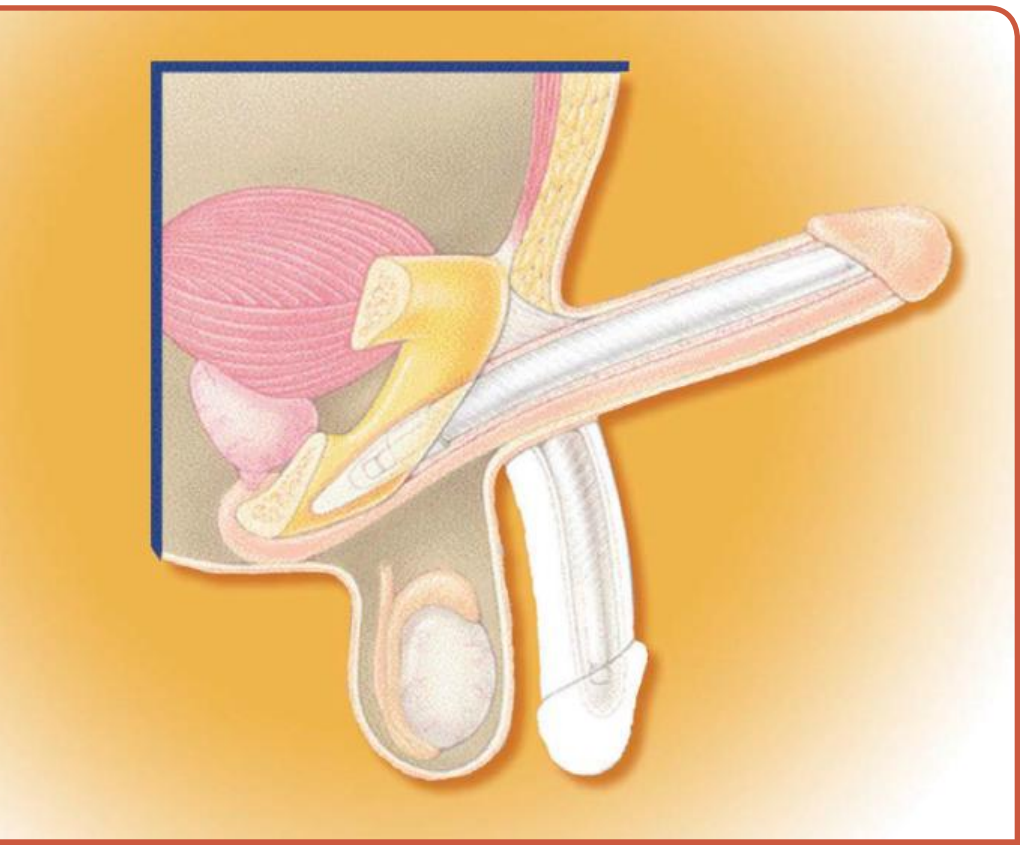
PATHOPHYSIOLOGY

The patient was diagnosed with a malfunctioning penile implant. The patient had an inflatable implant inserted three years prior to this surgery.[11] The implant malfunctioned because the balloon or reservoir was leaking fluid.

The inflatable prosthesis has two silicone rods that are surgically placed inside both sides of the corpus cavernosum of the penis.[9] A pump and a reservoir are attached together with tubes. The balloon or reservoir is filled with liquid and is placed underneath the sartorius muscle and the adductor magnus muscle, the muscles of the groin. The pump lies in the scrotum and is attached with tubing to the reservoir and the silicone rods that are placed in the penis. The implant inflates and the liquid is displaced or transported to the silicone rods in the corpus cavernosum of the penis. The water transports to and from the reservoir

LEARNING OBJECTIVES

- Learn about the procedure for the implantation of a penile prosthesis
- Compare the pros and cons of the different types of penile implants
- Identify the equipment needed to insert a penile prosthesis
- Examine the complications that can occur with a penile implant
- Access the relevant anatomy and physiology associated with this procedure



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and the pump. This action inflates and deflates the penis.[14]

The fluid leak can occur in any part of the prosthesis. This type of complication can occur immediately following surgery. This is due to improper implantation of the prosthesis or a defect in the product. This requires the implant to be replaced by a surgeon.[2] Improper implantation is only one of the problems that can occur with a penile implant. Other complications can include tubing kinks, aneurysm, lack of dilation of the cylinders, breakage of the wire, silicone spillage, loss of rigidity to the prosthesis, erosion of the reservoir, spontaneous deflation, spontaneous inflation, penile curvature or pump or pump reservoir migration. Most male patients receive penile implants in order to treat erectile dysfunction. Medications also can help with ED and surgery is considered a last resort. Erectile dysfunction occurs more frequently in the United States because the life expectancy is rising. It mostly affects males that are 65 and older.[1] "Approximately 25 million American men and their partners are affected by erectile dysfunction, the inability to achieve an erection."[3] There are different causes of erectile dysfunction. The nerves of the penis could be damaged by a pelvic surgery. A prostatectomy is an example of a pelvic surgery that can lead to erectile dysfunction. "Erectile dysfunction is essentially a vascular disease."[1] Some other causes of ED include diabetes mellitus and cardiovascular disease.

Males that suffer from type 2 diabetes have a higher risk of ED, and advancing age increases the risk by more than 15 percent. "It is been estimated that about 35-75% of men with diabetes will experience at least some degree of erectile dysfunction during their lifetime."[13]

The nerves in the penis and the small blood vessels that supply the penis become damaged due to diabetes mellitus. The hormones produced in males may still allow them to feel like they can achieve an erection, but they physically are unable to.[13]

Cardiovascular disease also is associated with erectile dysfunction. In males, smaller blood vessels in the extremities and the penis are the first parts in the body that have poor circulation due to vessel damage. "Studies estimate vascular diseases may be responsible for causing erectile dysfunction in as many as 50 to 70 percent of men who develop the condition." Erectile dysfunction can be a sign of heart disease since it is usually caught first; if males are experiencing erectile dysfunction they should seek medical attention to check for any problems with cardiovascular disease.[12]

DIAGNOSTIC TESTING

A patient history and physical is taken for every patient. For this patient, the physician conducted an H&P and a physical examination. The doctor then inflated the prosthesis to make a diagnosis. An X-ray also was taken. Radiographic studies are done to find any malfunctions in the penile implant. A contrast medium is used to fill the inflatable implant. This allows the doctor to see how the implant is situated and to see if any fluid is leaking from it. The physician will take an X-ray of the implant while it is inflated and then again when it is deflated, allowing the physician to analyze the entire prosthesis system.[2]

RELEVANT ANATOMY AND PHYSIOLOGY

The penis, the male reproductive organ, is composed of spongy tissue and is separated into three parts. The parts are called the corpus. "The cavernous structures of the penis, the two corpora cavernosa are positioned on the dorsal side of the penis and lie side by side.[5] The third corpus is called the corpus spongiosum. The corpus spongiosum is smaller and houses the urethra. The corpus spongiosum eventually forms the glans penis; this is the distal portion of the penis. The corpora cavernosa are surrounded by connective tissue; this attaches the corpus spongiosum to the corpora cavernosa. The foreskin, also called the prepuce, starts at the base of the penis and extends over the glans penis. The foreskin is not thick and does not contain hair.[5] The foreskin can be removed by a circumcision, but it is not necessary.[3] The head of the penis is called the corona. "The urethra passes through the corpus spongiosum and opens to the exterior via a slit-like opening, the external urethral orifice or meatus."[5]

The penis' blood supply comes from the dorsal artery and the central artery. The two central arteries run through the corpora cavernosa and the dorsal arteries are located on the dorsal side of the penis. The veins of the penis are called the dorsal veins and the external pudendal veins. The dorsal veins are located next to the dorsal arteries and the pudendal veins are located at the base of the penis. The dorsal nerve also runs on the dorsal side of the penis.

The process of an erection occurs because of the autonomic nervous system and the arteries and veins of the penis. "Sexual arousal stimulates parasympathetic nerves in the penis to release a compound called nitric oxide, which activates the vascular smooth muscle enzyme guanylyl cyclase."[3] This causes the rise in blood flow into the penis. The blood enters the corpora cavernosa and creates

COMPARING IMPLANT TYPES

The decision about which type of implant is based on a patient's preference and his medical situation. Factors including age, risk of infection, and health conditions, injuries or medical treatments should be considered before a penile prosthesis surgery.[13]

TYPE OF IMPLANT	PROS	CONS
Three-piece inflatable	• Creates a more natural erection than a semirigid implant • Creates a firmer erection than a two-piece implant • Takes pressure off the inside of the penis when deflated, reducing the chance for injury	• Has more parts that could malfunction than any other implant • Requires the most extensive surgery of any implant • Requires a reservoir inside the abdomen
Two-piece inflatable	• Requires a less complicated surgery than the three-piece implant • Creates a more natural erection than a semirigid implant • Takes pressure off the inside of the penis when deflated, reducing the chance for injury	• Requires more extensive surgery than does a semi-rigid implant • Is mechanically more complicated than a semirigid implant • Results in a bulkier scrotum than a three-piece implant • Provides less firm erections than a three-piece implant
Semirigid	• Requires the least extensive surgery of all implant types • Has fewer parts than any other implant, so less chance of malfunction	• Results in a penis that is always slightly rigid • Is more difficult to conceal under clothing than other devices • Puts constant pressure on the inside of the penis, which can cause injury in some men

> The decision about which type of implant is based on a patient's preference and his medical situation. Factors including age, risk of infection, and health conditions, injuries or medical treatments should be considered before a penile prosthesis surgery.

an erection.

The external genitalia of the male are the penis and the scrotum. The scrotum contains the testes. The tunica albuginea surrounds each testicle. The tunica albuginea is made up of connective tissue. The tunica vaginalis covers the tunica albuginea and the spermatic cord. The nerves, testicular artery, and testicular vein insert into the testes on the posterior side; the tunica vaginalis does not cover this part of the testicle. Each testicle contains seminiferous tubules. "A large number of convoluted seminiferous tubules lie between the septa of the testis. There are approximately 800 of these tubules."[5] The seminiferous tubules help in the production of spermatozoa. The tubules eventually leave each testicle and enter into the epididymis.[3] The epididymis receives blood from the vessels that branch off of the testicular artery.

The sperm runs through the vas deferens after the epididymis. These eventually form into the seminal vesicle and the ejaculatory duct. The urethra is connected to the ejaculatory ducts and the sperm is emptied into the urethra.

SURGICAL INTERVENTION

The room set up for this specific insertion of a penile implant consisted of a normal set up. The operating table was placed in the center of the room and the anesthesiologist cart was placed at the head of the operating table, above the patient's head. The surgical technologist opened the pack on the back table and began the sterile set up. The surgical team consisted of a surgeon, a surgical first assistant and a surgical technologist. The sterile set up began approximately 20 to 30 minutes prior to the patient's arrival. Some of the supplies opened onto the back table included a Lonestar Retractor, the Dura Hooks to the Lonestar Retractor, Heagar Dilators, the surgeons gloves, suture, #15 blade, bulb syringe, extra Mayo stand cover, Foley catheter tray and instrument sets.

BACK TABLE SET-UP

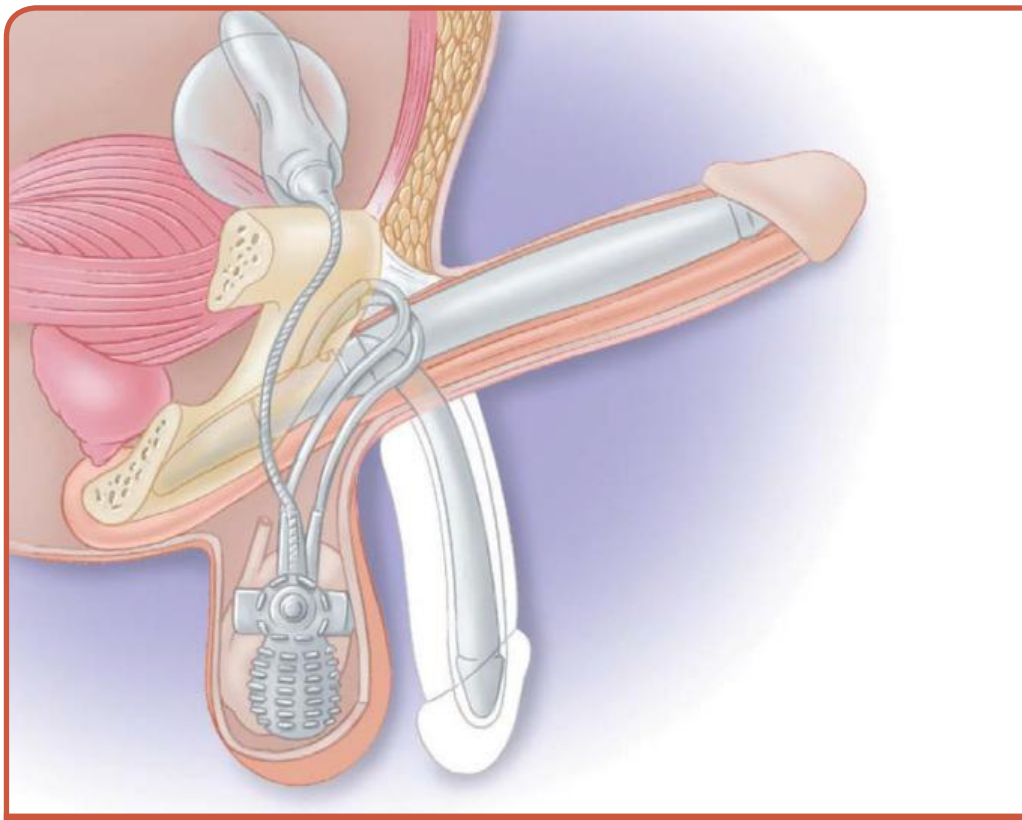
After the supplies were opened, the surgical technologist scrubbed in and began organizing the back table with all of the opened supplies. For this procedure, four blue towels were laid out; two vertically at the end of the table and two horizontally in the middle of the table. This allowed for more durable protection of the sterile field. Two Mayo stands were brought into the room prior to set up. The surgical technologist placed the Mayo stand covers over the Mayo stands. Two blue towels were set out on each of the Mayo stands and tucked in. A blue drape sheet was placed over one Mayo stand in order to prevent lint from getting on the instruments from the blue towels. The basin was moved to the corner of the table and the sharps box, kidney basin, small basin and medicine cups were organized on the table. The surgical technologist checked the indicators on the instrument sets one at a time. The drapes were stacked on the left side of the table and placed in the order that they would be draped on the patient. An extra basin was opened on a single ring stand.

Once everything was organized, the surgical technologist called the circulator over to start the initial count. Both the circulator and the surgical technologist counted the sharps, sponges, suction tip and scratcher. The sharps counted were the suture needles, tip for the electrosurgical pencil, knife blades and the Dura Hooks from the Lonestar Retractor. The circulator wrote down the count on the white board and a sheet of paper. The instruments were not counted during the initial count because the abdominal cavity would not be entered during this procedure. Once the count was complete, the surgical technologist asked the circulator for all of the medications, irrigation, sterile water and alcohol to be poured onto the sterile field. Each solution was poured one at a time and the surgical technologist labeled each basin or medicine cup with the correct name and percentage.

MAYO STAND SET-UP

After the initial count, the first Mayo stand was set up. The surgical technologist removed two Army-Navy retractors, two Mayo clamps, six Allis clamps, two DeBakey forceps, curved Mayo scissors, straight Mayo scissors and the Met-

zenbaum scissors from the instrument set and organized them on the Mayo stand. Two Raytec sponges and the #15 knife blade were placed on the Mayo stand. The Mayo-Hegar needle holder was used to load two 2-0 Vicryl CT-1 sutures, one dyed and one un-dyed, and placed them on the Mayo stand. The second Mayo stand was for the penile implant as well as a right angle clamp, Iris scissors and a retractor. A small basin was filled with irrigation, a mix of saline and polypeptide antibiotic, would help get rid of bacteria in the wound when irrigating it.



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PREPARATION OF THE PATIENT

Once the surgical technologist set up the preoperative sterile field, the patient was ready to be brought into the operating room by the nurse. The nurse introduced the patient to everyone in the room and asked him to state the name of the surgery he was receiving and the site of the surgery. The gurney was then locked and parked next to the operating table. The patient was transferred from the gurney to the table and positioned by the staff. The anesthesiologist gave the patient some oxygen and began to intubate him. After the patient was positioned, the nurse began the patient skin prep.

POSITION AND POSITIONING AIDS

The patient was placed in the supine position. His arms were extended out on padded arm boards at a 90-degree angle bilaterally and restrained with safety straps.[11] The patient's legs were separated in order to allow access to the penis and scrotum. All boney prominences, including the elbows and the heels of the foot were padded with egg crates. Padding also was placed under the patient's head for head support. A blanket was placed over the patient's arms to prevent hypothermia. The patient was an older male so the surgical team was aware of any places on the patient's body that would be prone to pressure injuries. "These areas include the occiput, scapula, olecranon, sacrum, ischial tuberosity and calcaneus."[5] After the patient was positioned, the electro-surgical unit dispersive pad was placed underneath the patient's left lower buttocks.[11]

SKIN PREP AND PREP SOLUTION

Before the skin prep was initiated, the circulator had to shave the patient. The patient's hair on the scrotum and part of the shaft of the penis was removed with clippers. This was done for the peno-scrotal incision.[10] Once the shave was finished, the circulator began the skin prep. A povidone-iodine scrub and solution was used for the prep.[11] A drape was placed in order to cover the anus of the patient to prevent infection. The entire perineal area was prepped. The scrotum and penis were prepped first, starting at the incision site. The prep extended up to the patient's umbilicus and down to the patient's mid thighs. The prep extended laterally down to the operating table on both sides.

DRAPING

The surgical technologist began the draping process along with the surgeon. The surgeon placed one folded blue towel under the scrotum. Then, four folded blue towels, three folded toward the surgical technologist and one folded away, were handed to the surgeon one by one and placed around the patient's surgical site or the pubic area. Once

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the four blue towels were placed by the surgeon, the surgical technologist grabbed and passed the drape. A laparotomy drape was placed on the surgical site; the bottom of the drape was extended over the patient's lower extremities and then the top of the drape was extended toward the patient's head. The anesthesiologist secured both sides of the drape to the IV poles.

SUPPLIES

A small plastic blue drape was needed for the Mayo stand with the implant. A #15 knife blade was needed for the incision and a #10 blade was needed to cut the previous penile implant. The suture was organized on the back table. The suture included: 2-0 Vicryl CT-2 (X3), 3-0 Vicryl SH (X3) and a 4-0 Vicryl PS-1. The suction tubing and the electrosurgical pencil were brought up to the sterile field by the surgical technologist and then the surgeon threw the cord and tube off to the circulator so they could be plugged in. The suction tube and electrosurgical pencil cord were secured to the drape using nonperforating towel clip from the instrument set. One basin set was needed and another sterile basin was opened onto a single ring stand to be used as a bird bath. It was filled with alcohol that was used for the surgical team to dip their hands into. Two bulb syringes were needed for irrigation, and lubricant was used for the Hegar dilators. Other supplies used included pop-up light handles, a needle magnet and a needle counter, gloves for all of the sterile team members, sterile marking pen and labels for labeling the medications used during the procedure, a 10 cc syringe with a 22-gauge needle for the injection of the local anesthetic and a Foley catheter with a drainage unit.[10] A semi-rigid penile implant was also requested by the surgeon since the inflatable implant malfunctioned in the patient. The type of implant used was the AMS Spectra Concealable Penile Prosthesis.

INSTRUMENTS AND EQUIPMENT

A sequential compression device with disposable leg wraps was applied to the patient's legs in order to prevent emboli and thrombi. The suction tube was hooked up to a suction unit. The last piece of equipment included the electro-surgical unit.

A minor instruments tray was necessary for basic instruments used during the procedure. A penile instrument set was also necessary. Heagar dilators were needed to dilate the corpus cavernosum of the penis. The 11/12, 13/14 and 15/16 dilators were used during the procedure. The Lonestar Retractor with Dura Hooks was requested by the surgeon for the retraction of the skin flaps. A caliper was needed to measure the diameter and the length of the corpus cavernosum on both sides of the penis. This was necessary to request the correct size implant. Mayo clamps were used to load the Dura Hooks and to stabilize the Foley Catheter after it was inserted into the penis. Other instruments used during the procedure included a #3 knife handle, Debakey forceps, Weitlander Retractor, straight Mayo scissors, curved Mayo scissors, Allis Clamps, Babcock clamps and Mayo-Heagar needle holders.

MEDICATIONS

A 3% hydrogen peroxide solution was used for irrigation. Normal saline or sodium chloride (1000 cc) was used for irrigation as well. 50,000 units of polypeptide antibiotic and 1 gram of kanamycin were mixed with the normal saline and used as irrigation. A bupivacaine hydrochloride (0.25%) with epinephrine (50 mL) was used for the local anesthetic. The anesthesiologist gave the patient gentamycin and cefazolin through the IV.[11]

PROCEDURAL STEPS

After the patient was brought into the room and prepped and draped, the surgical technologist brought up the first Mayo stand and adjusted it over the patient's legs. Then the back table was brought up to the sterile field and the second Mayo stand was placed by the side of the back table. The suction tube and electrosurgical pencil cord were secured to the drape with a nonperforating towel clip and the holster for the electrosurgical pencil was secured to the Mayo stand with the scratcher attached to it. The sterile basin filled with 70% isopropyl alcohol was brought up to the field and all of the team members dipped their hands in the alcohol. The surgical technologist provided the Foley catheter with lube on the tip for easy insertion. The catheter was secured to the drape with a Mayo clamp because it needed to stay sterile throughout the entire case so the surgeon can easily identify the urethra.

After the Foley was secured, the surgical technologist provided the 10cc syringe for the injection of the local anesthetic. Bupivacaine hydrochloride (0.25%) with epinephrine was used for the local anesthetic. As the surgeon injected the anesthetic at the base of the penis, the surgical technologist verbalized to the circulator the amount of local anesthetic used and then placed two laparotomy sponges on the field. The syringe with the needle on it was prepared and it was placed next to the sharps box on the back table. Then the surgical technologist provided the #15 knife blade and the surgeon made an incision at the base of the penis on the dorsal side that was approximately four centimeters in length. The surgeon cut through the subcutaneous tissue and the connective tissue of the penis using the electrosurgical pencil and smooth tissue forceps. Hemostasis was achieved with laparotomy sponges. The thin layers of subcutaneous and connective tissue were dissected and the Weitlander Retractor was positioned for better visualization so the surgeon could identify the structures of the penis. The tunica albuginea was then dissected with the electrosurgical pencil and the corpora cavernosa was exposed.

> A penile prosthesis is usually the last option for men that suffer from erectile dysfunction. There are other, safer options that a man can do before having surgery.

After the Weitlander Retractor was removed, the surgeon placed the Lonestar Retractor around the wound. The Dura Hooks were loaded and passed to the surgeon on Mayo clamps and the surgeon carefully placed eight hooks for retraction.

After the retractor was placed, the previous implant was identified. The surgeon cut the right side of the inflatable prosthesis and removed it. The surgeon placed a 2-0 Vicryl CT-2 dyed suture on the right side. This suture was placed as a stay suture. The straight Mayo scissors were used to cut the suture. The dilators were soaked in the warm saline with a polypeptide antibiotic and then dipped in a lubricant. The surgeon removed the other side of the implant (left side) and once both sides of the prosthesis were removed, it was placed in the kidney basin and passed off to the product rep. The surgical technologist provided the 3-0 Vicryl SH un-dyed suture on a needle holder so the surgeon could place the stay suture on the left side. After the stay sutures were placed, the surgeon irrigated the wound to prevent infection. The surgical technologist had two basins for two different medications; one basin contained 3% hydrogen peroxide solution and the other contained polypeptide antibiotic mixed with saline. These were used for irrigation. The surgeon then irrigated the corpora cavernosa and alternated between both irrigates.

The surgeon started with an 11/12 Heagar dilator and then used a 13/14 dilator to obtain an accurate measurement of the corpora cavernosa. When the corpora cavernosa was dilated, the surgeon took the distal and proximal measurements. The measurements were added and the correct size semi-rigid prosthesis was obtained by the rep. The surgical technologist provided the surgeon with the antibiotic and he applied the antibiotic with a bulb syringe.

Before the surgeon began to place the new implant in the patient, he had the sterile team dip their hands in the

basin with alcohol. The irrigation basin was used to sterilize both sides of the prosthesis before insertion. The Lonestar Retractor and the Dura Hooks were removed and the surgical technologist loaded a 2-0 Vicryl CT-2 suture on a needle holder and passed it to the surgeon with smooth tissue forceps. This suture was the dyed suture and it was placed on the same side as the other dyed suture (right side). The surgical technologist provided the first assistant with the straight Mayo scissors. Then the surgeon performed the same actions on the left side. The skin was closed with 4-0 Vicryl PS-1 suture and the surgical technologist initiated the final count.

Adhesive strips were cut in half for placement on the wound. Dressings were then placed over the adhesive strips. The surgical technologist placed the bandage rolls over the dressings and then taped them to the patient with two-inch paper tape. These materials were used for penile support.

POSTOPERATIVE CLEANUP

The drape was removed in order to wipe off the patient. A wet sponge cleaned up the prep and blood and another sponge dried off the patient. The surgical technologist began the cleanup process while the anesthesiologist woke the patient. All instruments were gathered and placed in the case cart for sterilization. By the time the surgical technologist was finished gathering the instruments, the patient was ready to be transferred to the gurney. The surgical technologist was in charge of moving the feet of the patient. Once the patient was transferred, the surgical tech finished the cleanup.

SPECIAL CONSIDERATIONS

The patient was not obese or a diabetic. A sequential compression device was placed under the operating table and disposable leg wraps were placed on the patient's legs to prevent embolus formation and thrombus formation.

Another consideration is that there was an implant placed in the patient. The circulator recorded these all of these descriptions in the patient chart. The chart read, "Procedure Implants, OR description: AMS Spectra Concealable Penile Prosthesis, diameter 14 mm, length 20 mm, total quantity: 1, Lot number: 637210005, catalog number: 720056, and site implanted: penis."[11]

COMPLICATIONS

In this case, the patient had no intraoperative or postoperative complications while he was at the hospital. Possible complications can include hemorrhaging, surgical site infection, malfunctioning implant and injury to nearby structures such as the urethra, blood vessels, testicles and nerves of the penis. Infection is a major complication that must be considered during this procedure. A surgical site infection occurs in about five percent of patients who undergo a penile implant surgery for the first time. However, the risk almost doubles if the patient is replacing a previous implant. This may require the patient to go through another surgery to fix the problem if antibiotics do not clear the infection.[8]

Newer models have fewer problems, but a penile implant can malfunction over time. According to statistics, "85% or more are working well 5 years after implantation and 67% are working at 10 years."[8]

POSTOPERATIVE CARE

The patient was transported from the operating table to the gurney and was transported to the PACU. A jock-strap and gauze dressing was in place when the patient arrived in the PACU. The anesthesiologist then assessed the patient based on the Aldrete scale. The patient was assessed right away and every fifteen minutes afterward for a total of one hour.[12]

The patient's pain was controlled with oral medications and needed oxygen immediately after surgery to maintain a level of 90% oxygen saturation. Fifteen minutes after surgery his oxygen saturation was at 97%. The patient's vital signs were then compared with his preoperative values. His blood pressure and his pulse rate were both within 20% of his preoperative values. His blood pressure was 97/71 and his pulse rate was 88 beats per minute.[12]

The patient was ready to be released after one hour. His dressings remained clean and dry and the patient was discharged to his wife.

OTHER OPTIONS BESIDES SURGERY

A penile prosthesis is usually the last option for men that suffer from erectile dysfunction. There are other, safer options that a man can do before having surgery. Medications can be taken orally by the patient. These medications raise the amount of nitric oxide in the body which produces an erection. However, they do cause certain side-effects and a physician will decide what medications, if any, the patient can take to help with erectile dysfunction. Low hormone levels also may have an effect on the ability to produce an erection. In this case, the physician may put the patient on the hormone testosterone. Penis pumps are also an option for the male patient. The pump works like a vacuum to bring blood through the corpora cavernosa, which creates

an erection. After the erection occurs, a ring is placed at the base of the penis in order for the man to keep his erection.[7]

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Mass Casualty on Deck

After a Routine Fighter Jet Landing Goes Awry, a Sailor is Rushed to the Ship's OR for an Emergency Amputation

V/R HM1 (SW/AW) Daniela M Dietsch, CST

One hundred miles off shore, during a night recovery training session, a fighter jet was approaching the aircraft carrier USS Kitty Hawk. The aircrew stationed in the tower observed the incoming aircraft while the landing signal officer stood by on a platform to help guide the jet on to the deck. The crew determined that the in-bound aircraft was an F/A-18 Super Hornet Jet. This information was immediately forwarded to the arresting-gear officer. The sailors below deck, in the engine room, were notified to activate the mechanism controlling the arresting gear. For a Super Hornet Jet, the four thick, strong wires are required to safely stop the aircraft. But, on that day, something went wrong.

Photo courtesy of the US Navy

As the Super Hornet's tail hook snagged the wire and landed, the wire continued to stretch and tore, whipping back and wrapping itself around a helicopter. The tip of the wire continued across the deck and struck six sailors working nearby. The aircraft was lost to sea, and one sailor's leg was wounded so gravely that it would have to be amputated. "Mass casualty on deck" was announced over the intercom and the entire crew responded to their stations. Hospital corpsman reported to the scene and immediately transported the patients to the medical department where the operating room was located.[1,6,7]

LEARNING OBJECTIVES

- Learn how to prep skin for an above-the-knee amputation
- Identify what tools are necessary for this procedure
- Review the possible complications associated with any type of amputation
- Examine the surgical technologist's role in an above-the-knee amputation
- Define phantom pain and how it relates to limb removal

INITIAL CARE AND TRANSPORT

The medical response team was on the scene less than a minute after the alarm was sounded. The hospital corpsman who assisted the sailor with the leg injury immediately applied gauze to reduce the bleeding, as the rest of the team attended to other casualties. While the medical officer was radioed and informed of the possible surgery, stretcher-bearers ran across the flight deck to help the corpsman transport the patient to the medical department. The patient was strapped down to a rigid stretcher, stabilizing the leg and making sure not to cause further injury. The two sailors that took on the responsibility of stretcher-bearers safely maneuvered their way through passageways and down steep ladder wells to the medical department. Once they arrived, the patient was immediately transferred to a gurney and prepped for surgery. He was put on oxygen via a face mask, changed into a patient gown and had IVs started. The sailor was covered with warm sheets and blankets to maintain his temperature within normal levels.

PREOPERATIVE PATIENT CARE

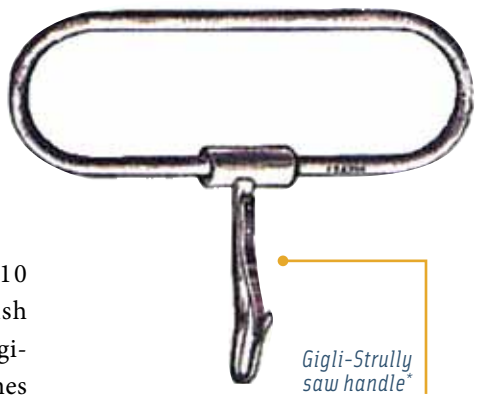
The circulator transported the patient to the operating room and then assisted with transferring him to the operating table. The anesthesia provider was at the patients' head, monitoring the patient and maintaining the airway; the circulating nurse stood on the right side of the operating table to receive the patient; one of the surgical technologists was on the left side of the gurney to help lift the patient onto the table; and the surgeon was at the patients' feet, protecting the injured leg. A minimum of four people are required to transfer a patient to the operating table. Once anesthesia was induced, the patient was placed in the supine position with both arms extended (palms facing upward and the angle of the armboard less than 90 degrees) and secured on padded arm boards. The safety strap was placed over the unaffected extremity only (2 inches proximal to the knee), as to not impede surgery on the affected leg. The chart was checked for any patient sensitivities and allergies, which included food, latex and medications. The dispersive electrode for the electrosurgical unit was applied to the skin on the unaffected thigh; the pad should never be applied over bony prominences, joints, implants, tattoos or scars. Hair removal occurs if it interferes with the incision. In this case, hair needed to be shaved so there would be good contact with the skin. The technique for shaving depends on the thickness and density of hair on the leg. Some surgeons may request a circumferential shave prep. If this type of shave occurs, an assistant may be needed to elevate the leg.[7] After the shave, the skin needs to be cleaned so there is good contact. The pad should be placed as close to the surgical site as possible.

*Liston amputating knife**

INSTRUMENTATION, EQUIPMENT AND SUPPLIES

A basic orthopedic set was needed along with an electrically or pneumatically powered oscillating saw. Some ships may be equipped with nitrous oxide or battery operated power saws, but that is not standard. A Gigli saw or the Satterlee bone saw needs to be available in case the power saw fails. If power is used, the surgical technologist must test the instruments in advance to ensure proper function. All accessory items need to be available and checked for the correct fit. An orthopedic pack, basin set, extra #10 blades and an electrosurgical pencil need to be opened to start the case.[3]

A forced-air warming blanket is used to cover the parts of the body not involved in the surgery. Trauma patients' temperature needs to be stabilized to decrease the risk of hypothermia and the risk it can have on the heart and postoperative healing. A pneumatic tourniquet is applied to the affected limb to reduce blood loss during surgery. Inflation time of the tourniquet needs to be annotated and tracked. The surgical technologist or circulator should notify the surgeon once the tourniquet has been on for an hour. Inflation time should not exceed one and a half hours at 300-350 mmHg on a lower extremity. If the surgery takes longer, the site should be covered and the tourniquet deflated for approximately 10 minutes to re-establish blood flow. Electrosurgical and suction machines



*Gigli-Strully saw handle**

* From ASSOCIATION OF SURGICAL TECHNOLOGISTS. Surgical Technology for the Surgical Technologist, 3E. © 2008 Delmar Learning, a part of Cengage Learning, Inc.

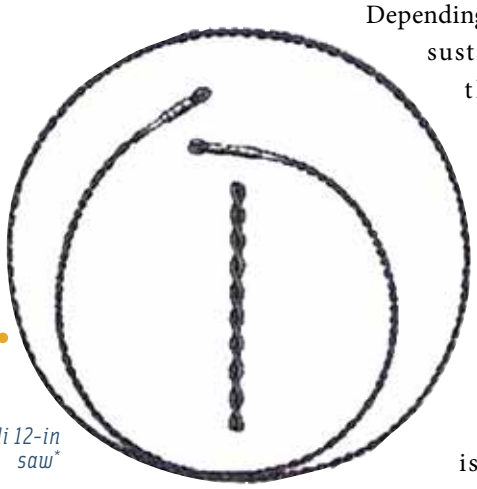
also will be used during the case to coagulate vessels and maintain good visualization of the operative field during the procedure.

SKIN PREP AND DRAPING

For this specific procedure, the tourniquet is applied first around the thigh; stretchable cotton material will be needed to separate the skin from the tourniquet. Contaminants should be washed out of the wound with sterile water before starting the skin prep. The prep area may extend from mid-abdomen to the ipsilateral side and down to where the leg was injured; this area may change according to the surgeon's preference. While prepping the skin, a sponge used on the affected area should never be taken back over a clean area.[2] Prep should extend from the incision site to the toes, including the foot. A circumferential motion should be used when prepping the leg.[2] In order to prevent damaging the skin and a starting a fire, preparation solutions should not be left to pool under the tourniquet or patient. While draping, the extremity is carefully abducted and the foot and leg are covered with a stockinette. An impervious large sheet is draped over the end of the table, covering the unaffected leg. A split sheet is placed under the affected thigh and wrapped around to the top. A towel folded into thirds, lengthwise, is placed around the top of the stockinette and fastened with a towel clip. The U-drape is then draped proximally to the thigh. The leg is passed through a fenestrated extremity drape to complete the draping sequence. If available, an extra Mayo stand cover can be used to contain the amputated portion of the leg.

PROCEDURE

The patient will be in the supine position and a bump can be placed under the hip to control rotation of the limb. Depending on the patient's sustained injuries, the limb may be exsanguinated using Esmark before inflating the tourniquet. As a safety measure, time out is called before the surgery begins and the entire surgical team confirms the patient and the procedure to be performed.



Gigli 12-in saw*

> A basic orthopedic set was needed along with an electrically or pneumatically powered oscillating saw. Some ships may be equipped with nitrous oxide or battery operated power saws, but that is not standard. A Gigli saw or the Satterlee bone saw needs to be available in case the power saw fails.

After the time out check list is completed, the surgeon uses a #10 knife blade to make a V-shaped incision in the anterior-posterior plane above the distal femur to get the greatest skin length possible. This flap will provide for easy coverage and tension-free closure of the stump. The surgical technologist should have lap sponges available to keep the site clear of fluids and decrease the risk of exposure.[2] To control bleeding, the electrosurgical pencil will be used to coagulate open vessels. Sharp and blunt dissection is carried down to the muscular layer. The posterior, lateral and anterior muscle compartments are identified and isolated to create musculocutaneous flaps for coverage of the femoral stump. The distal adductor canal is entered and the superficial femoral artery, vein and saphenous nerve are all ligated and divided separately. Tying vessels separately prevents arteriovenous fistulas or aneurysms from forming. The surgical technologist should have clamps and nonabsorbable ties available for the surgeon to doubly clamp, ligate and cut the identified vessels. Muscles are further transected circumferentially with a #10 blade. The sciatic nerve is held with a Schnidt clamp, cut and ligated with the electrosurgical

Satterlee bone saw*

pencil. The femoral periosteum is then elevated with either a #10 knife blade or a key elevator. To transect the bone the surgeon can use the Gigli saw, Satterlee bone saw, or, if available, a power saw.[2] Bone edges can be smoothed with a Putti-bone rasp. The wound is then irrigated with copious amounts of normal saline with or without antibiotics. Once hemostasis has been established, wound closure can begin. A myoplasty, where antagonistic muscle and fascia groups are sutured together, is used to cover the distal end of the femur. A closed wound drainage system, such as the Hemovac, may be used to remove blood, fluids and air from the site. Utilizing a drainage system prevents edema as well as dead space within the surgical wound from forming.

> A pneumatic tourniquet is applied to the affected limb to reduce blood loss during surgery. Inflation time of the tourniquet needs to be annotated and tracked.

COMPLICATIONS

There are physical risks with any amputation that include, but are not limited to, heart complications such as a heart attack or heart failure; infection at the site of the amputation; pneumonia; blood not being restored to the affected area; and phantom limb pain.[7] Studies have shown that emergency amputations that result from a traumatic injury have fewer complications than planned amputations. This is because many planned amputations are the result of diabetes not being managed, so the patient may already be in poor health. Many emergency amputations occur in relativity healthy younger patients, who may have a better chance of recovering from the physical trauma of removing a limb.[8]

Psychological impacts after an amputation are also prevalent and should be taken into consideration. Many amputees say it is common to experience negative thoughts and emotions after the procedure. This may be especially true for those who had an emergency amputation, as they did not have time to mentally prepare themselves for the loss of a limb or body part. Other psychological effects can include depression, anxiety, denial, grief and suicidal feelings. Most of these issues can be helped with antidepressants or counseling.[8]

POST-OP

Amputation wounds are covered with bandages or plaster dressings and a tube may be placed under the skin to drain away excess fluids from the affected area. Bandages usually remain in place for a week post-op to reduce risk of infection. Painkillers are usually administered to help with pain as many amputees report considerable pain following the surgery. In the weeks following the surgery, amputees continue to meet with multiple health professionals to learn how to cope with the changes to their body. It is normal to be transferred from the surgical ward to another part of the hospital to assist in recovery. Amputees will meet with an occupational therapist to arrange a home visit to identify what aids the patient will need to make their home more accessible. Many amputees will meet with professionals to learn more about prosthetic limbs.[8]

Stump care is extremely important to make sure patients reduce their risk of infection. Stumps should be washed frequently with an antibacterial soap and dried completely and carefully. Some doctors will suggest using an unmedicated talcum powder to help reduce sweat around the stump. Patients caring for the stump need to regularly check for signs of infection including warm, red and tender skin; discharge or fluid or pus; and swelling of the skin.[8]

In this specific case, a bulky, soft dressing with a pressure wrap was applied to the stump. The soft-tissue dressings with compression wrap required an even distribution of pressure to avoid possible limb strangulation. Once the dressing was applied and the patient was extubated, the anesthesia provider and circulating nurse transferred the patient to a gurney. Since the security of the airway is the anesthesia provider's responsibility, he or she will indicate when the patient can be moved. Due to the limited staffing on the ship, the circulating nurse and a hospital corpsman recovered the patient and prepared him for the flight to a hospital. Once the patient's vital signs were stable and his pain was under control, a helicopter flew him to Naval Hospital in Yokosuka, Japan. A flight nurse and corpsman, who were specialized in respiratory therapy, accompanied the patient during the flight to monitor his vital signs and make the transfer as easy as possible. He spent a few days in the Intensive Care Unit in Yokosuka before he was transferred to the United States.[6]

ABOUT THE AUTHOR

HM1 (SW/AW) Daniela M Dietsch, USN, CST, joined the US Navy on October 3, 2001, graduated from bootcamp in December 2001 and then went to HM School. She graduated from Hospital Corpsman Basic at Naval Hospital Corps School Great Lakes in April 2002. Daniela's first duty station was Naval Hospital Yokosuka, Japan, from May 2002 to July 2005. She graduated the Surgical Technology Program at the Naval School of Health Sciences (NSHS) in March 2006. She then was stationed at Naval Hospital Guantanamo Bay from April 2006 to October 2007, and transferred to United States Naval Ship (USNS) Mercy, TAH-19, homeport San Diego, California, where she was stationed from October 2007 to October 2010. Daniela has participated in two humanitarian missions, Pacific Partnership 2008 and 2010 while stationed on USNS Mercy. She is currently stationed at the Naval Medical Training Center, Medical Education and Training Campus, in Fort Sam Houston, Texas.

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Unraveling Phantom Pain

ONCE THOUGHT AS A PSYCHOLOGICAL PROBLEM, STUDIES HAVE SHOWN PAIN IS REAL

JODI B FARMER, AST EDITOR

Phantom Pain

This term is usually associated with people who have lost an extremity such as an arm or a leg and the pain comes from a body part that no longer remains.[4] But it can also occur to other body parts including the breast, penis, eye or tongue after they are surgically removed. At one time it was thought that this post-amputation phenomenon was just a psychological problem. But now doctors believe that these are real sensations that originate in the spinal cord and brain. For some people, phantom pain improves over time. For others, it will always remain a challenge.

History

Although the official term "phantom limb" wasn't coined until 1871, it is believe that the first description of the post-amputation sensation was used by a French military surgeon in the 1500s. This surgeon noticed that many of his amputee patients complained of pain in the missing limb following the surgery.[3] During the decades to follow, more doctors, noted that their patients mentioned that they had pain in the place of the amputated limb. Traumatic amputations were seen during World War I and II as well as Vietnam where landmine explosions were common. Today, many amputees experience some kind of phantom sensation, whether the sensations are painful or not.

Characterizing the Pain

Most people who have had a body part removed, report that they feel that it is still there. The following include characteristics of phantom pain: onset within the first few days of amputation; tendency for the pain to come and go; seeming to come from the part of the limb farthest from the body; be described as shooting, stabbing, boring, squeezing, throbbing or burning; and may be triggered by weather changes, pressure on the remaining limb, emotional stress or stump irritation.[2] Also of note is that phantom pain may be relative to whether a person had a body part removed because of a traumatic injury or for a vascular condition, such as diabetes. One study showed that vascular amputees showed more pain between pre-amputation pain and phantom pain in the first two years after the amputation, whereas traumatic amputees' phantom pain only appeared directly after the amputation.[3]

Mixed signals of the brain may partially explain why amputees have the sense of phantom pain. Studies have shown that during imaging scans, specific portions of the brain show activity when the person feels phantom pain. After a limb or body part is removed, the spinal cord and brain lose input from the missing part and tries to adjust to this detachment. It results in tangled sensory wiring that sends signals to a remaining body part.

Other theories of what causes phantom pain includes decreased blood flow to a particular area, muscle spasms, damaged nerve endings, scar tissue left over from the amputation, illness, pressure on the stump or removed area and physical memory of pre-amputation pain.[1] The peripheral theory is based off the result of nerve endings forming around the stump that generate electrical impulses that the brain then interprets as pain. The central theory

states that the brain has "memory" of the amputated limb or removed body part. The symptoms of pain are recreated from memory, but fail because the brain does not receive the feedback it was expecting. The spinal theory is based off the lack of sensory input from the removed body part that then causes chemical changes in the central nervous system.

A series of mechanisms may be involved in generating phantom pains. It is suspected that "the unraveling of neuroplastic changes in periphery, spinal cord and brain are also reflected in many of the features seen in phantom pain phenomena."[3] Cerebral reorganization may play a large part in the sense of phantom pain. Magnetoencephalographic techniques have tracked cerebral reorganization as there has been a linear link between pain and the degree of reorganization. Researchers also found a subcortical connection as techniques were used to define pain patterns and noticed that an unusually large thalamic stump representation.[3]

Surgical treatment for phantom pain has been attempted, although many times it is unsuccessful at fully reducing pain in the affected areas, and many times often reappears.

Treatment

Treatment for phantom pain is classified in three categories: medical, non-medical and surgical. Certain medications can help block pain or relive nerve injury pain. Lidocaine has been shown to be effective in controlling neuropathic pain.[3] A number of other oral medications are still being studied including carbamazepine. This drug was created to treat epilepsy and it is thought that it can help decrease stump pain as signals coming from nervous system activity are reduced.[5]

Non-medical treatments can be combined with non-invasive techniques to help reduce pain in affected areas. Transcutaneous electrical nerve stimulation (TENS), vibration therapy, acupuncture, hypnosis, biofeedback and electroconvulsive therapy are various ways to alleviate stump pain. Electrical stimulation of the spinal cord, deep brain structures and motor cortex has shown to relieve phantom pain as well, although the effect may decrease over time.[3]

Mental imagery may offer the best non-medical solution. Relating to the central theory of phantom limb pain, mental exercises may prove to be effective to send the brain the feedback it is looking for. Studies have shown that if patients spent time imagining using their phantom limb, such as bunching up their toes, they experienced a reduction in pain.[5]

Surgical treatment for phantom pain has been attempted, although many times it is unsuccessful at fully reducing pain in the affected areas, and many times often reappears.

Benefit of Phantom Pain

Believe it or not, some experts feel that phantom pain should be viewed as an ally to the human body. Some say that phantom pain can be used to help detect other imbalances in one's health and well-being. By focusing on where the phantom pain is located, a connection may be made to an imbalance with an internal organ such as a kidney or spleen. Some people also have found phantom pain useful when using a prosthetic limb as the pain alerts them to any issues with the limb.[1]

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Increasing Airflow:

The Process of Inferior Turbinate Reduction

TAMMY CAPESTRO, CST, EMT-B

Inferior turbinate reduction is a procedure utilized to decrease the size of the inferior turbinate in order to increase airflow through the nasal passageway. The primary diagnosis facilitating the need for turbinate reduction is turbinate hypertrophy, an enlargement of the turbinates, which may cause partial to complete nasal obstruction. The primary symptom of turbinate hypertrophy is congested breathing, which is usually more prevalent at night. Additional symptoms may include epistaxis (nosebleed), chronic infection, snoring and headache. Development of turbinate hypertrophy can be attributed to frequent or chronic upper respiratory infections, rhinitis (allergic or vasomotor) and repeated exposure to environmental irritants.[1] It also can be caused by a compensatory response to a deviated septum, in which case a septoplasty may be indicated in conjunction with the turbinate reduction procedure in order to correct both afflictions.[2]

LEARNING OBJECTIVES

- Identify the primary diagnosis facilitating the need for turbinate reduction
- Define what turbinates are and where they are located
- Review the equipment necessary to perform an inferior turbinate reduction
- Examine the role of the surgical technologist in this type of procedure
- Access the post-operative process and learn about the complications associated with an inferior turbinate reduction

The turbinates (conchae) are located on the lateral walls of the nasal passageway. There are typically three turbinates on each side. Turbinates are long, narrow, spongy bone shelves that protrude into the nasal cavity bilaterally. Several types of cells compose the mucous membrane that lines the nasal cavity and covers the turbinate. The two main types of cells that pertain to the area of the nose that contains the turbinates are columnar epithelial cells, which are ciliated, and the goblet cells that secrete mucous. Interspersed between the goblet cells are nerve and lymphatic cells which are capable of responding to climatic conditions, anatomical differences and adapting to physiological needs. The superior turbinate, the smallest in size, serves to protect the olfactory bulb. The middle turbinate is larger and acts as a buffer to protect the sinuses from direct nasal airflow. The inferior turbinate is the largest of the three. The majority of nasal airflow is filtered, heated and humidified via this turbinate. It is enriched with receptors that relay airflow pressure information and temperature status via the trigeminal nerve. The medial aspect of the nasal passageway is created by the nasal septum.[3] The turbinates are vascular structures; therefore, the primary contraindication for turbinate reduction surgery is a coagulopathy. Patients should discuss changes in anticoagulation therapy prior to the procedure with their treating primary care physician. A 72-hour cessation of anticoagulant medications prior to the procedure is necessary. If radio frequency turbinate reduction is the surgeon's preferred methodology, contraindications for patients with pacemakers should be noted.[4]

TURBINATE ADVANCES

Turbinectomy procedures date back to the late 1890s and into the early 1900s. These procedures fell out of favor due to gross complications.[5] Poor aseptic technique leading to infection, as well as an unfavorable condition now known as empty nose syndrome, left patients with a poor prognosis for symptom relief. As technology advanced, more surgeons began to perform reduction procedures, leaving an adequate amount of turbinate tissue rather than radical turbinectomies, in which all of the turbinate tissue is removed. Several advances, including nasal endoscopy, microdebridement and radio frequency coblation, have been implemented throughout the last 40 years making inferior turbinate reduction more effective.

PREPARATION

When setting up for a turbinate reduction, the surgical technologist should always be prepared with the proper instrumentation, equipment and supplies necessary to facilitate a septoplasty procedure since these two procedures often are performed in conjunction with each other. A nasal tray consisting of a Cottle elevator, freer elevator, Boies elevator, Joseph scissor, Jansen Middleton septum forceps, #3 knife handle, Cottle septum knife, Ferris Smith forceps, bayonet forceps, Gorney turbinate scissor, Cottle osteotome, Cottle mallet, Blakesley sinus forceps, Tru-cut endoscopic biters and various sizes of nasal speculums may be necessary for any approach. A manufacturer's prepared ENT pack will provide most of the necessary supplies such as surgical towels, X-ray detectable sponges, X-ray detectable cottonoid sponges, ENT split sheet drape, head turban drape, Mayo stand cover, 10mL syringes, surgical gowns, suction tubing, medication cups and marking pen with labels.

Mayo stand set up preoperatively

The equipment and supplies utilized will vary depending on the surgeon's methodology and preference.

The patient is brought to the operating room on a gurney, then transferred to the operating table using proper body mechanics and positioned onto the operating table in the supine position with arms tucked bilaterally, utilizing padding to protect all pressure points particularly the ulnar nerve. A pillow is positioned under the patient's knees to alleviate stress to the lower back. A safety strap is placed 2 inches proximal to the patient's knees. After induction of general anesthesia and intubation, the table may be rotated 90 degrees in order to facilitate room for the surgeon, who stands laterally on the patient's right side. A premedication table is set up for the surgeon. It consists of a 10mL syringe containing 1% lidocaine with a 1:100,000 concentration of epinephrine, a 25-gauge needle, a medication cup containing ½-inch x 3-inch cottonoid sponges soaking in 4:1 mixture of oxymetazoline hydrochloride and 4% cocaine, a nasal speculum, bayonet forceps, a pair of Joseph scissors and two X-ray-detectable 4" x 4" sponges. All medications are clearly labeled and all items are included in the initial count. The surgeon will use the nasal speculum for visualization. The scissors are used to trim excessive nasal hair away from the surgical site. The surgeon will proceed by injecting the 1% lidocaine with epinephrine into the turbinate. The cocaine and oxymetazoline hydrochloride soaked cottonoids are then placed into the nasal passageway using bayonet forceps to facilitate anesthesia and vasoconstriction. The surgeon may advise the anesthesia provider to assess any adverse changes in the patient's vital signs.

Several advances, including nasal endoscopy, microdebridement and radio frequency coblation, have been implemented throughout the last 40 years making inferior turbinate reduction more effective.

The patient's face is prepped with a povidone iodine solution using caution to prevent the prep solution from entering the eyes. The patient is draped by squaring off the nasal area with four towels. A split sheet is secured to cover the patient's body. A turban or ¾ sheet may be utilized to cover the patient's head. The Mayo stand is brought into position and the suction tubing, with a 10 or 12 French Frazier suction tip attached, should be secured to the field immediately. Depending on the methodology planned, other equipment may be needed to secure the field, such as the bipolar cord, microdebrider hand piece with irrigation and suction tubing, radio frequency wand and/or endoscopic camera with sinus lens and light cord.

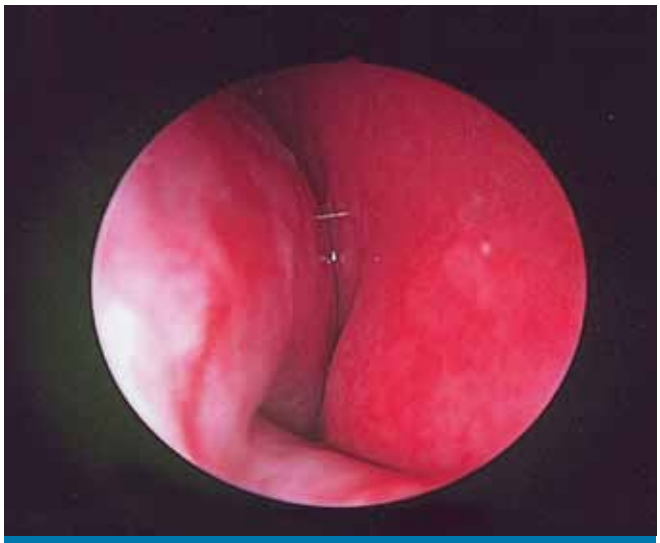
The procedure can be performed under direct visualization using a nasal speculum or via a 4mm, endoscopic sinus lens with light cord attached. A camera may be attached to the lens to facilitate photo documentation of the case. An anti-fog agent should be available to the surgeon when using the endoscopic approach.

The surgeon retrieves the previously placed cottonoids using bayonet forceps. A knife, either a sickle blade or #15 blade on a #3 or #7 knife handle, is passed to make an incision into the anterior portion of the inferior turbinate. A freer elevator is introduced into the incision to elevate the turbinate tissue for resection. At this point of the procedure, different methods of resection can be utilized. A surgeon performing an extramural excision will require an endoscopic biter to remove turbinate tissue. In submucous resection, the turbinate is elevated and the tissue is resected from below the mucosal surface of the turbinate.

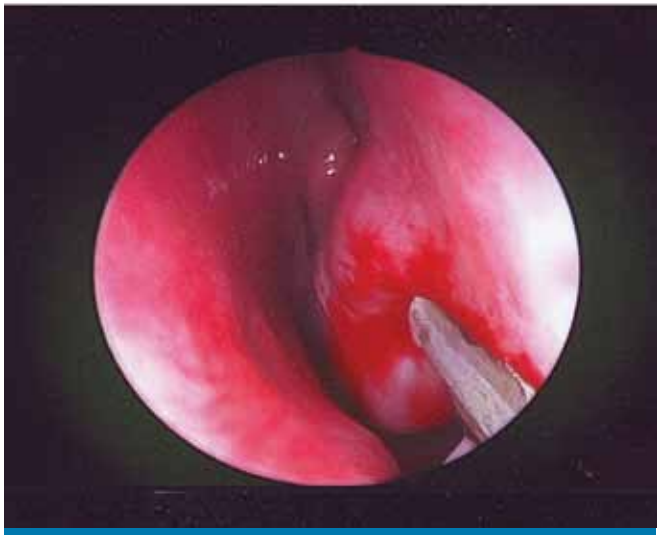
Surgeons preferring radio frequency coblation ("cold" ablation) will prime the coblation wand with a layer of saline gel. This provides a conductive solution that, combined with radiofrequency, will create a small plasma field, thus causing a molecular breakdown in the tissue.[6] The radio frequency wand is activated via a foot pedal controlled by the surgeon. The wand is placed submucosally within the turbinate. A count of 10 seconds is performed to control the amount of tissue ablated in one area.[7]

The microdebrider may be introduced to irrigate and debride the turbinate. It consists of a corded handpiece with a 2.9mm turbinate blade attached. Suction and irrigation tubing connects to the base of the handpiece. The shaver blade resects tissue working in an oscillating fashion and is activated via foot pedal. The surgical technologist should be prepared to ream the device with a small wire brush should an occlusion occur within the shaft.

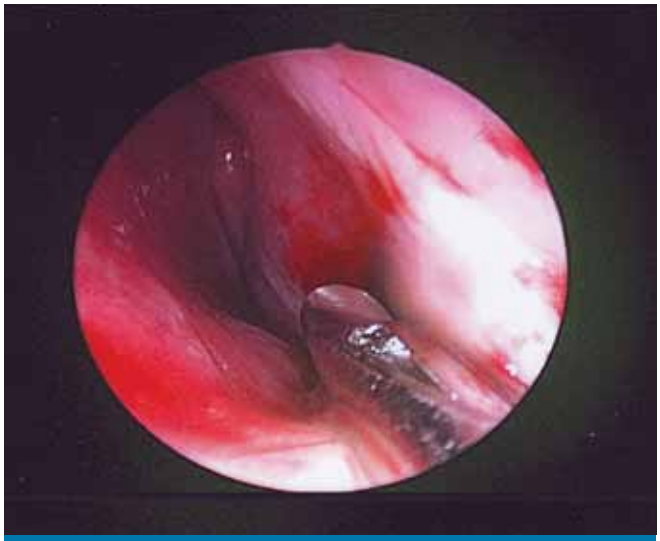
The vascularity of the turbinates will require continuous hemostatic technique throughout the procedure. Various methods of hemostasis may include injection of 1% lidocaine with a 1:100,000 concentration of epinephrine, 4% cocaine and oxymetazoline hydrochloride soaked cottonoid



Inferior turbinate hypertrophy



Injection 1% Lidocaine with epinephrine 1:100,000



Insertion of microdebrider into inferior turbinate

Intraoperative photographs courtesy of Sean B Bailey, MD, ENT Otolaryngology

sponges and bipolar electrosurgery. Adequate suction will be necessary during the entire procedure.

The surgeon must be cautious not to remove too much of the receptor-rich turbinate tissue. The turbinate should not be reduced more than 25 percent to ensure it does not interfere with receptor feedback. The surgeon resects the turbinate in an anterior to posterior fashion. A Boies elevator may be utilized to reduce the septum. Once the airway is adequately improved, the surgeon will irrigate using 0.9% sodium chloride solution in a bulb syringe. The surgical technologist should be sure to observe and report the amount of irrigant used during the procedure in order to establish estimated blood loss for the patient's operative record. The surgeon may utilize bipolar electrosurgery at this time to control any bleeding. Additional hemostatic agents to help control postoperative bleeding may be introduced into the nasal cavity. A powdered topical dressing or a gelatin sponge should be available. In addition, dissolvable splints or packing may be instilled in the nasal passageways to ensure lateralization of the inferior turbinates. Prior to the insertion of splints or packing, the surgical technologist will perform the final count and give a report of the amount of irrigation and medications used to the circulator. The patient's nose and face is cleaned with wet and dry sponges and a mustache dressing is secured.

POST-OP

Prior to extubation, the anesthesia provider will utilize suction to remove additional bloody drainage from the nasopharynx. The patient is transferred from the operating table to the gurney using proper body mechanics and transfer technique. The head of the gurney will be elevated to approximately 45 degrees to facilitate adequate drainage and to reduce the risk of aspiration. The patient's vital signs are monitored and intensity of pain will be monitored in the post anesthesia care unit (PACU). Analgesics will be provided according to the physician's orders. It may be necessary for the PACU staff to change the nasal drip pad upon saturation. The patient is allowed a regular diet and encouraged to have intake by mouth prior to being discharged. It will be necessary for a responsible adult to receive all postoperative instructions, provide transportation and observe the patient for 24 hours. An appropriate postoperative record of level of discomfort, oral intake and dressing assessment should be documented within the patient's record.

RECOVERY

A follow up appointment in the surgeon's office should be scheduled approximately seven to 10 days postoperatively. The patient may experience nasal drainage, swelling, dryness, and pain for approximately seven to 14 days postoperatively. Postoperative instructions may include not to blow the nose and to sneeze with the mouth open. Patients should avoid strenuous activity. The surgeon may order a daily sinus irrigation using a saline spray to alleviate dryness. The patient will be prescribed an analgesic for pain, an antibiotic to reduce the risk of infection and possibly a steroid to reduce inflammation and promote healing.

COMPLICATIONS

The most severe complication of inferior turbinate reduction is empty nose syndrome. In these cases too much of the receptor tissue is removed. The brain interprets the message that the nasal passageway is blocked, when in fact the turbinate is reduced and the passageway is open. This may lead to pain, chronic dryness and nasal infections. Patients may use saline sprays or gels to lessen the symptoms.[8] Empty nose syndrome has a poor prognosis for recovery without further surgical intervention.

ABOUT THE AUTHOR

Tammy Capestro CST, EMT-B, lives in High Ridge, Missouri. She worked as an on-the-job trained surgical technologist for an orthopedic surgical center while attending the St Louis Community College surgical technology program. She graduated and earned her certification in 2006. She completed EMT licensure in 2009. Tammy is currently enrolled in St Louis Community College's Nursing Program. She is employed by USPI SSM St Clare Surgical Center in Fenton and serves as an adjunct instructor for the surgical technology program at Sanford Brown College, St Peters.

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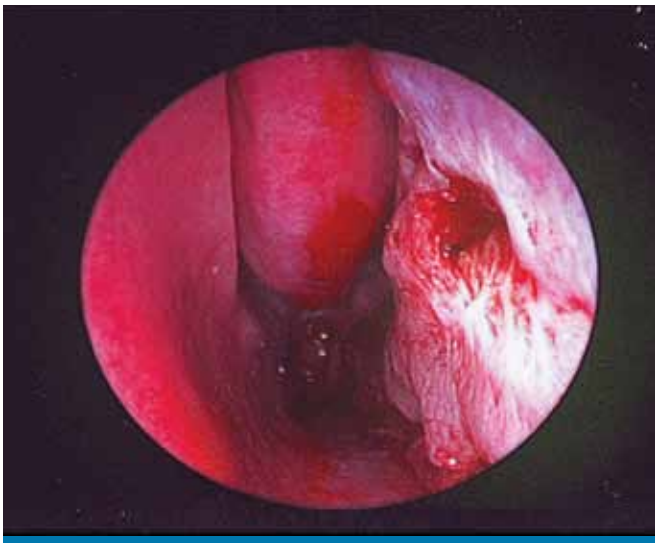
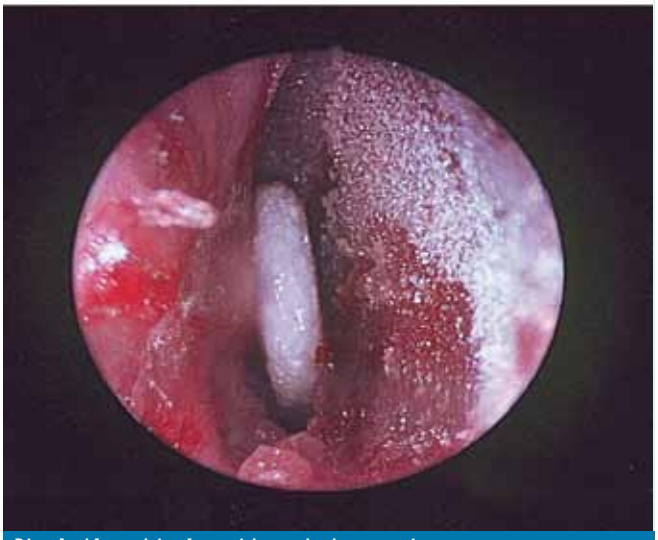


Reduced inferior turbinate



Dissolvable pack in place with powder hemostatic agent

The surgeon must be cautious not to remove too much of the receptor-rich turbinate tissue. The turbinate should not be reduced more than 25 percent to ensure it does not interfere with receptor feedback.

CE Exams

ORIF: PIP Fracture and Dislocation of the Fingers

1. **Which surgical discipline was not included in Dr. Bunnell's ideal combination for hand surgery?**
   a. Orthopedic
   b. Plastic
   c. ENT
   d. Neuro

2. **Dr. Bunnell believed that improper ___ contributed to the less-than-complete restorations of function that he observed.**
   a. Splinting
   b. Traction
   c. Skin grafting
   d. All of the above

3. **The ___ is the primary ligament in the PIP joint.**
   a. Volar plate
   b. Metacarpophalangeal
   c. Interphalangeal
   d. None of the above

4. **One of the most common injuries to the PIP joint is a ___.**
   a. Fracture
   b. Sprain
   c. Dislocation
   d. rupture

5. **X-rays are used ___ to determine if there is an avulsion fracture to the joint.**
   a. Preoperatively
   b. Intraoperatively
   c. Postoperatively
   d. All of the above

6. **Most PIP injuries are treated ___.**
   a. Surgically
   b. Using the "shotgun" technique
   c. Nonsurgically
   d. Using ORIF

7. **Cefazol is administered preoperatively as a/an __.**
   a. Anti-inflammatory
   b. Antibiotic
   c. Nerve block
   d. None of the above

8. **The articular surface of the joint is exposed using the ___.**
   a. Shot gun technique
   b. Bruner incision
   c. Bunnell incision
   d. Volar approach

9. **Postsurgical physical therapy begins ___.**
   a. The day of surgery
   b. Within a month
   c. Within a week
   d. As soon as tolerable

10. **___ are required elements to an ORIF modular hand set.**
    a. Screwdriver blades
    b. Plate-and screw-holding forceps
    c. Depth gauges
    d. All of the above

Microbiology Review: Pathogens and Disease

1. **Biological classification as we currently know it was developed by ___.**
   a. Charles Darwin
   b. Carl Linnaeus
   c. The Human Genome Project
   d. None of the above

2. **The components of a cell do not include ___.**
   a. Nucleus
   b. Plasma membrane
   c. Cytoplasm
   d. Organisms

3. **The liquid portion of the cell is called ___.**
   a. Cytoplasm
   b. Protoplasm
   c. Fat droplets
   d. Vacuole

4. **Cristae occur in the ___ of the cell.**
   a. Vacuole
   b. Storage granules
   c. Mitochondria
   d. All of the above

5. **There are ___ types of RNA**
   a. 2
   b. 3
   c. 4
   d. 5

6. **In ___, the centromere splits and the duplicated chromosomes separate.**
   a. Prophase
   b. Metaphase
   c. Anaphase
   d. Telophase

7. **The resting/functional phase between cell divisions is called ___.**
   a. Prophase
   b. Metaphase
   c. Anaphase
   d. None of the above

8. **Diffusion, osmosis and filtration are examples of ___.**
   a. Passive transport
   b. Active transport
   c. Exocytosis
   d. None of the above

9. **There are ___ types of microorganisms that can cause disease in humans.**
   a. 2
   b. 3
   c. 4
   d. 5

10. **___ are susceptible to antibiotics.**
    a. Viruses
    b. Fungi
    c. Bacteria
    d. All of the above

Microbiology Review: Pathogens and Disease – questions cont.

11. ___ must be within a living cell to replicate.
a. Viruses
b. Fungi
c. Bacteria
d. Protozoa

12. ___ are spread by fecal-oral contamination and vectors, like mosquitos.
a. Viruses
b. Fungi
c. Bacteria
d. Protozoa

13. ___ do not contain genetic material.
a. Fungi
b. Protozoa
c. Prions
d. None of the above

14. Communicable diseases are classified as ___.
a. Epidemic
b. Endemic
c. Pandemic
d. All of the above

15. Skin, body secretions and body reflexes are examples of ___.
a. Nonspecific defenses
b. Specific defenses
c. Immunization
d. Acquired immunity

16. An animal's inability to contract the measles is a result of ___.
a. Naturally acquired immunity
b. Inborn immunity
c. Acquired immunity
d. Antibodies

17. ___ contain acids, enzymes or chemicals to destroy potential invaders.
a. Saliva
b. Tears
c. Sweat
d. All of the above

18. The "first line of defense" in the body's immune system is ___.
a. Reflexes
b. Skin
c. Inborn immunity
d. Acquired immunity

19. A genome represents ___.
a. Linnaean categorization
b. All DNA in an organism
c. The genes of a given organism
d. A social project

20. Potential applications for the Human Genome Project include ___.
a. Molecular medicine
b. DNA forensics
c. Energy sources
d. All of the above

Transmission-Based Isolation Precautions in the OR: Critical Practices to Prevent the Spread of Infectious Diseases in the Operative Setting

1. **HAIs cost American hospitals ___ per year.**
   a. $15-25 million
   b. $28-45 million
   c. $10-15 billion
   d. $28-45 billion

2. **All infectious diseases are caused by a ___.**
   a. Port of entry
   b. Microorganism
   c. Chain of infection
   d. Vector

3. **According to published estimates, ___ or HAIs may be preventable.**
   a. 70
   b. 50
   c. 90
   d. 30

4. **Infectious diseases are spread ___ by methods.**
   a. Airborne
   b. Direct contact
   c. Vector
   d. All of the above

5. **Current illness and lack of vaccination increase ___ of/to disease.**
   a. Susceptibility
   b. Indicators
   c. Methods
   d. None of the above

6. **Infectious agents do not include ___.**
   a. Fungi
   b. Bacteria
   c. Infected individuals
   d. Protozoa

7. **Breaking the "Mode of Transmission" link involves all but ___.**
   a. Airflow control
   b. Isolation precautions
   c. Sterilization
   d. Aseptic technique

8. **___ is not an airborne infectious agent.**
   a. HIV
   b. Bioaerosols
   c. Varicella virus
   d. None of the above

9. **Microorganisms on or within body sites without infection is/are called ___.**
   a. Fungal spores
   b. Colonization
   c. Respiratory droplets
   d. Multi-drug-resistant organisms

10. **Infections directly related to receiving medical care are called ___.**
    a. Health care-associated
    b. Nosocomial
    c. Opportunistic
    d. Viral

Transmission-Based Isolation Precautions in the OR: Critical Practices to Prevent the Spread of Infectious Diseases in the Operative Setting- questions cont.

11. AIDS is an example of a/an ___ infection.
- a. HAI
- b. Nosocomial
- c. Opportunistic
- d. Bacterial

12. Blood-borne pathogens include ___.
- a. HCV
- b. HIV
- c. HBV
- d. All of the above

13. PPE is not associated with ___.
- a. Barrier precautions
- b. Contact precautions
- c. Droplet precautions
- d. Engineering controls

14. Respirators are required PPE when dealing with airborne infectious agents ____.
- a. Less than five microns in size
- b. Less than seven microns in size
- c. More than five microns in size
- d. All of the above

15. ___ are worn in general patient care situations.
- a. Respirators
- b. Procedure masks
- c. Surgical masks
- d. Eye protection

16. Respirators are required when handling patients with ___.
- a. Tuberculosis
- b. SARS
- c. Small pox
- d. All of the above

17. Containing ones own airborne droplets is a part of ___.
- a. Respiratory hygiene
- b. Hand hygiene
- c. Cough etiquette
- d. A & C

18. Organisms that live in or on another and take advantage of the host are ___.
- a. Viruses
- b. Parasites
- c. Protozoa
- d. Prions

19. MRSA and Vancomycin-resistant enterococci (VRE) are examples of ___.
- a. Airborne infectious agents
- b. Prions
- c. Multidrug Resistant Organisms
- d. All of the above

20. Those who contract VRE typically have ___.
- a. Recently had surgery
- b. Weakened immune systems
- c. Chronic illnesses
- d. All of the above

Malignant Hyperthermia Crisis

1. **The malignant Hyperthermia Association of the United States (MHAUS) recognizes which of the following areas as having a high level of malignant hyperthermia susceptible individuals?**
   a. Maine
   b. California
   c. West Virginia
   d. Texas

2. **The most common initial sign of a malignant hyperthermia crisis is:**
   a. Masseter muscle rigidity
   b. Elevated temperature
   c. Tachycardia
   d. Hypertension

3. **Vials of dantrolene sodium are reconstituted with water because:**
   a. malignant hyperthermia already causes an increase in sodium in the vascular spaces.
   b. the vials also contain enough electrolytes to maintain an isotonic solution.
   c. using sodium chloride would cause renal failure due to the increase in vascular volume
   d. the reconstitution should be a slow process and saline works too quickly.

4. **Which of the following medications should be included in a malignant hyperthermia cart?**
   1. furosemide
   2. diltiazem
   3. insulin
   4. sodium bicarbonate
   a. 1 & 2
   b. 1, 3 and 4
   c. 1, 2, 3 and 4
   d. 2, 3 and 4

5. **You are providing a tour of the operating room to some surgical technology students. One asks why the malignant hyperthermia cart is located in the PACU. You respond:**
   a. "Patients have been known to have an MH crisis after the surgery is completed."
   b. "This location helps us to distinguish between the regular crash cart and the malignant hyperthermia cart."
   c. "It is normally stored in the pharmacy; there must be a patient with high potential for a crisis scheduled."
   d. "The PACU area has a warmer ambient temperature and it prevents deterioration of the medication."

6. **Your next surgical patient is known to have a parent who demonstrated a high fever after surgery. Which statement indicates an appropriate set-up of the operating room for this patient."**
   a. The temperature in the room is decreased to 65° Fahrenheit.
   b. The anesthesia machine is prepared with fresh soda lime.
   c. Anesthesia has succinylcholine prepared for rapid sequence intubation.
   d. The malignant hyperthermia cart is stocked and placed in the PACU.

7. **The surgeon complains that the patient's abdominal muscles are "tight" and that the patient is getting too little anesthesia. The patient's skin is bright red and the end-tidal carbon dioxide level has risen sharply in the last few minutes. Anesthesia personnel should:**
   a. Provide more inhalation agent to deepen the patient's anesthesia level.
   b. Apply a bispectral monitor to determine if the patient is too light.
   c. Discontinue the inhalation anesthetic and call for the MH cart.
   d. Administer another dose of succinylcholine to cause the muscles to relax.

Malignant Hyperthermia Crisis – questions cont.

8. **Patient's suffering an MH crisis in the intraoperative setting should be monitored postoperatively for:**
   1) respiratory difficulties
   2) renal failure
   3) cardiac arrhythmias
   4) recurrence of MH
   a. 1 and 2 only
   b. 3 and 4 only
   c. 1,2 and 4
   d. 1, 2, 3 and 4

9. **Your next patient states that his mother had an MH crisis during surgery. However, the patient had genetic testing which showed no mutations of the RyR1 gene. Which statement best describes his risk for developing a crisis.**
   a. Low risk: genetic testing is the standard test for measuring MH susceptibility.
   b. High risk: family history is more important than genetic testing or contracture tests for determining susceptibility.
   c. High risk: muscle biopsy contracture tests are the best method of determining MH susceptibility.
   d. Low risk: transmission of the mutation is linked to paternal genes, not maternal.

10. **Which of the following are considered "late signs of a malignant hyperthermia crisis?**
    1) unexplained tachycardia
    2) oliguria
    3) increased temperature
    4) prolonged bleeding
       a. 1, 2, and 3
       b. 2, 3 and 4
       c. 1, 3 and 4
       d. 1, 2 and 4

Surgery for Space Exploration

1. **___ is the study of the effects of space on the human body.**
   a. Space medicine
   b. Aerospace physiology
   c. Spaceflight deconditioning
   d. Long-term exposure

2. **___ are among the most common changes the body experiences during space flight.**
   a. Neurovestibular deficiencies
   b. Musculoskeletal deficiencies
   c. Immune deficiencies
   d. All of the above

3. **Hypervolemia causes all but ___.**
   a. Decrease in plasma volume
   b. Increase in red blood cells
   c. Reduced cardiac volumes
   d. Increased risk for arrhythmias

4. **Light-headedness and fainting are associated with landing day due to ___.**
   a. Orthostatic stress
   b. Immune deficiencies
   c. Spaceflight deconditioning
   d. Body fluid redistribution

5. **The most common medical condition experienced by astronauts is ___.**
   a. Spaceflight deconditioning
   b. Facial pallor
   c. Space motion sickness
   d. None of the above

6. **Spending two weeks in space can diminish a person's muscle mass by ___.**
   a. 5%
   b. 10%
   c. 15%
   d. 20%

7. **Muscle loss can be mitigated with ___.**
   a. Preflight exercise
   b. Exercise during flight
   c. Nutritional supplementation
   d. All of the above

8. **Blunt and penetrating trauma requiring surgery is unlikely to occur during ___.**
   a. Launch procedures
   b. Space walks
   c. Vehicle docking
   d. Servicing payloads

9. **The physical risk of ___ injuries is increased in space.**
   a. Dental
   b. Psychological
   c. Orthopedic
   d. Minor

10. **Obstacles for performing space surgery include limited ___.**
    1. Water
    2. Physical space on board
    3. Disinfectants
    4. Oxygen

    a. 2 and 3 only
    b. 1 and 2 only
    c. 1, 2 and 3 only
    d. All of the above

Surgery for Space Exploration – questions cont.

11. **___ is preferred anesthetic for use in space.**
    1. **Local**
    2. **Inhalational**
    3. **Spinal**
    4. **Intravenous**

    a. 1 and 4 only
    b. 1 and 2 only
    c. 2 and 3 only
    d. 1, 3 and 4 only

12. **Challenges facing space surgery patients include ___.**
    a. Decreased wound healing
    b. Radiation
    c. Anemia
    d. All of the above

13. **Konstantin Tsiolkovsky is considered the ___.**
    a. Father of space surgery
    b. Father of Cosmonautics
    c. First space surgery patient
    d. First astronaut

14. **There is no gravity in space.**
    a. True
    b. False

15. **The mass of objects affected by microgravity ___.**
    a. Increases
    b. Decreases
    c. Remains the same
    d. Fluctuates

16. **Protein loss in space can be ___ that of people on bed rest on Earth.**
    a. Three times
    b. Equivalent to
    c. Less than
    d. None of the above

17. **Acute radiation syndrome is not caused by ___.**
    a. Large solar particle events
    b. High levels of solar activity
    c. Exposure to high doses of solar radiation
    d. High risk of hemorrhaging or death

18. **When something "floats" in space, it is due to ___.**
    a. Microgravity
    b. Optical illusion
    c. Zero gravity
    d. All of the above

19. **Resistance exercise and vitamins D and K are recommended during flight to combat ___.**
    a. Muscle atrophy
    b. Bone demineralization
    c. Immune dysregulation
    d. All of the above

20. **NASA technology has been used on Earth to ___.**
    a. Clean arteries nonsurgically
    b. Manipulate voice-controlled wheelchairs
    c. Create portable X-ray devices
    d. All of the above

Cannulated Retinal Surgery

1. **The ___ is a layer of blood vessels and connective tissue that supplies nutrients to the inner eye.**
   a. Sclera
   b. Conjunctiva
   c. Choroid
   d. Uvea

2. **The uveal tract does not include the ___.**
   a. Cornea
   b. Ciliary body
   c. Iris
   d. Choroid

3. **The ___ helps maintain the global structure of the eye.**
   a. Vitreous
   b. Ciliary body
   c. Endothelium
   d. Bowman's membrane

4. **Sharp images and color recognition are determined by the ___.**
   a. Rods
   b. Cones
   c. Ganglion cells
   d. Retina

5. **A pars plana vitrectomy removes ____.**
   a. Scar tissue
   b. Traction
   c. Membranes
   d. All of the above

6. **___ drops are administered to the operative eye prior to injection prep.**
   a. Lidocaine
   b. Bupivacaine
   c. Proparacaine
   d. None of the above

7. **The infusion line ___.**
   a. Maintains pressure in the globe
   b. Provides a port of entry for illumination
   c. Prevents leakage
   d. All of the above

8. **A/an ___ should be worn while sleeping for at least one week postoperatively.**
   a. Eye patch
   b. Pair of glasses
   c. Eye shield
   d. Sleep mask

9. **Exogenous endophthalmitis results from ___.**
   a. Complications of ocular surgery
   b. Penetrating ocular trauma
   c. Blunt ocular trauma
   d. All of the above

10. **The three points of insertion are not used for ____.**
    a. Infusion
    b. Insertion of vitrector
    c. Pressure relief
    d. Insertion of light source

Innovations in Endoscopic Sinus Surgery

1. **The OR must be equipped with these devices ___ for an endoscopic sinus surgery.**
   a. Video monitor display system
   b. High-definition camera
   c. Light source
   d. All of the above

2. **Balloon sinuplasty is a minimally invasive procedure performed during sinus surgery where a ___ is guided into the sinus then inflated.**
   a. Microdebrider
   b. Suction
   c. Sinus balloon catheter
   d. Sinuscope

3. **The goal of an ESS is to ____.**
   a. Ensure ventilation
   b. Restore mucociliary clearance
   c. Prevent sinus infection
   d. All of the above

4. **The nasal sinuses are comprised of ___.**
   a. Frontal and sphenoid sinuses
   b. Ethmoid and maxillary sinuses
   c. None of the above
   d. A and B

5. **Where did endoscopic surgery procedures originate?**
   a. United States
   b. Germany and Austria
   c. The Netherlands
   d. Australia

6. **Approximately how many Americans suffer from sinusitis yearly?**
   a. 37,000
   b. 37 million
   c. 31 million
   d. None of the above

7. **Symptoms of chronic sinusitis may include ____.**
   a. Headaches, facial pain, nasal drainage
   b. Nasal obstruction, halitosis
   c. Fatigue
   d. All of the above

8. **The nasal cavity is divided midline by the ___.**
   a. Nasal septum
   b. Turbinate bones
   c. Maxillary sinus
   d. Superior meatus

9. **Nasal polypectomy is the removal of ___ from the nasal cavity.**
   a. Mucous membrane
   b. Connective tissue
   c. Middle turbinate
   d. Polyps

10. **Although uncommon, what complications can arise from ESS?**
    a. Synechia
    b. Cerebral spinal fluid leakage
    c. Orbital hematomas
    d. All of the above

Automated Anesthesia and Natural Orifice Transluminal Endoscopic Surgery

1. **McSleepy is a _____.**
   a. Car
   b. Robotic system
   c. Computer
   d. None of the above

2. **Closed-loop anesthesia systems utilize complex ___ based on patient data.**
   a. Algorithms
   b. Pharmacokinetics
   c. Biological factors
   d. Computer systems

3. **McSleepy is commonly referred to as an ___ robot.**
   a. Surgery
   b. Anesthesiologist
   c. Anesthesia
   d. Excellent

4. **McSleepy lends itself to revolutionizing patient care by ___.**
   a. Improving patient care
   b. Giving more accurate dosing
   c. None of the above
   d. Both a and b

5. **Natural orifice transluminal endoscopic surgery shows potential to further alter the state of ___ and treatment.**
   a. Surgeries
   b. Disease diagnosis
   c. Recovery
   d. Internal complications

6. **NOTES has greatly enhanced recovery of the surgical patient while simultaneously decreasing ____.**
   a. Morbidity
   b. Postoperative pain
   c. Healing time
   d. All of the above

7. **The McSleepy anesthesia robot was combined with the DaVinci surgical robot to perform the world's first ____.**
   a. Total-robotic operation
   b. Heart surgery
   c. Knee replacement
   d. All of the above

8. **Natural orifice transluminal endoscopic surgery is a ____.**
   a. Large-scale procedure
   b. Minimally-invasive operation
   c. Laparoscopic procedure
   d. Both b and c

9. **NOTES utilizes the body's natural ___ to access internal abdominal organs and structures without leaving an external scar.**
   a. Fluids
   b. Clock
   c. Orifices
   d. Organs

10. **Five approaches to NOTES peritoneal access have been identified. They include ___.**
    a. Transcolonic
    b. Transgastric
    c. Transvesical
    d. All of the above

Automated Anesthesia and Natural Orifice Transluminal Endoscopic Surgery

11. NOTES is a scarless procedure that is a combination of ___ techniques.
a. Endoscopic
b. Laparoscopic
c. Both a and c
d. None of the abov

12. One critical drawback to NOTES is the lack of adequate surgical instrumentation and equipment needed to facilitate ___ procedures on humans.
a. Fully transluminal
b. Laparoscopic
c. Internal
d. External

13. As new NOTES technologies are developed they will lead us to ___.
a. No-scar surgery
b. Minimal complications
c. Both a and b
d. None of the above

14. Advancements in NOTES procedures will help with ____.
a. Time needed to administer anesthesia
b. Dissection
c. Decreases in tissue trauma
d. Elimination of muscle mass

15. ___ may very well revolutionize the healthcare industry.
a. Automated, closed-loop anesthesia systems
b. NOTES
c. McSleepy
d. All of the above

16. McSleepy monitors the patient's level of ___.
a. Pain
b. Consciousness
c. Muscle movements
d. All of the above

17. The natural orifice approach holds potential to ___ patient complications and ___ postoperative recovery time.
a. Increase, reduce
b. Reduce, improve
c. Raise, lower
d. Reduce, increase

18. Experimenters such as Reginald Bickford used ___ to monitor amounts of anesthetic administrated to the patient.
a. EEG
b. BIS
c. Both A and B
d. None of the above

19. McSleepy was successfully tested during a ___ procedure.
a. Anesthesia environment
b. Partial nephrectomy
c. Elbow replacement
d. Open heart surgery

20. Hemmerling described McSleepy as a ___.
a. Advanced robot
b. Humanoid anesthesiologist
c. Human counterpart
d. Human competitor

Minimally Invasive Posterior Spinal Fusion

1. **The CD Horizon® Sextant™ procedure is a new advancement in the treatment of ____.**
   a. Degenerative disc disease
   b. Spinal instabilities
   c. Heart transplants
   d. Both a and b

2. **This minimally invasive procedure requires patients to have single to multi-level ____.**
   a. Fusions
   b. Weak screws
   c. Degenerations
   d. Bone slips

3. **Once the tissues are dilated and retracted, a sharp, cannulated tap is placed over the ___ to prepare the pedicle for screw insertion.**
   a. Infuser
   b. Guidewire
   c. Mayo stand
   d. Screwdriver

4. **During the procedure, the surgeon inserts a mixture of ___ and bone chips along the lateral gutters of the posterior spinous process.**
   a. Lidocaine
   b. Epinephrine
   c. Osteogenerative protein
   d. Tissue

5. **Using a(n) ___, the surgeon removes small portions of bone from the lamina to gain entrance to the spinal canal.**
   a. Neuro-simulator
   b. Angled curette
   c. Guidewire
   d. All of the above

6. **Within ___ hours after the procedure, the patient is encouraged to ambulate to aid in the recovery process.**
   a. 6 to 12
   b. 1 to 2
   c. 24 to 48
   d. 3 to 4

7. **The most common complication of minimally invasive spinal fusions is a ____.**
   a. Dural tear
   b. Bleeding
   c. Discharge
   d. Posterior discomfort

8. **This minimally invasive approach is more attractive to patients who are candidates for spinal fusion because there is less ___.**
   a. Blood loss
   b. Postoperative pain
   c. Recovery time
   d. All of the above

9. **Using a(n) ___ on a bayoneted handle, the surgeon makes an incision into the annulus of the disc.**
   a. Screwdriver
   b. 11 blade knife
   c. 15 blade knife
   d. Neuro-simulator

10. **The fluoroscopy machines image the ___ and the ___.**
    a. Lateral lumbar spine and the stab incisions
    b. Anterior/posterior lumbar spine and the annulus
    c. Lateral lumbar spine and anterior/posterior lumbar spine
    d. None of the above

Exploring the Penile Prosthesis Procedure

1. **The most common reason for men receiving a penile implant is ____.**
   a. Erectile Dysfunction
   b. STDs
   c. Diabetes
   d. None of the above

2. **The two most popular types of implants are ___.**
   a. Semi-rigid
   b. Inflatable
   c. Rigid
   d. Both a & b

3. **A two-piece inflatable penile implant requires more extensive surgery than a ___.**
   a. Rigid implant
   b. Semi-rigid implant
   c. Limp implant
   d. Three-piece implant

4. **Diabetes can damage the ___ in the penis causing erectile dysfunction.**
   a. Nerves
   b. Dorsal arteries
   c. Small blood vessels
   d. Both a & c

5. **The inflatable prosthesis has two silicone rods that are placed inside both sides of the ___.**
   a. Reservoir
   b. Sartorius muscle
   c. Corpus cavernosum
   d. Adductor magnus muscle

6. **Complications that can occur with an inflatable penile prosthesis are ___.**
   a. Tubing kinks
   b. Aneurysm
   c. Silicone spillage
   d. All of the above

7. **The patient was positioned in the ___ position for the procedure.**
   a. Supine
   b. Lateral
   c. Distal
   d. Medial

8. **The prep for the penile procedure extended up to the patient's ___.**
   a. Umbilicus
   b. Mid thighs
   c. Anus
   d. Scrotum

9. **A(n) ___ was applied to the patient's legs to help prevent emboli and thrombi.**
   a. Compression Device
   b. Sequential Compression Device
   c. Cold wrap
   d. Ice pack

10. **A ___ was needed to measure the diameter and the length of the corpus cavernosum.**
    a. Dura Hooks
    b. Debakey Forceps
    c. Caliper
    d. Allis clamps

Exploring the Penile Prosthesis Procedure – questions cont.

11. The local anesthetic was a mixture of ___ and epinephrine.
a. Vicryl
b. Saline
c. Bupivacaine Hydrochloride
d. Kanamycin

12. During the procedure, the surgeon started with a ___ Heagar dilator.
a. 13/14
b. 15/16
c. 1/2
d. 11/12

13. After the stay sutures were placed, the surgeon irrigated the ___ in order to prevent infection.
a. Wound
b. Penis
c. Sutures
d. Foreskin

14. A surgical site infection occurs in about ___ of patients who undergo a penile implant for the first time.
a. 10 percent
b. 24 percent
c. 5.5 percent
d. 5 percent

15. If the patient is replacing a previous implant, the surgical site infection risk can ___.
a. Triple
b. Double
c. Stay the same
d. None of the above

16. Other options are available for treating erectile dysfunction. They include
a. Medication
b. Pumps
c. Hormone treatments
d. All of the above

17. The tunica vaginalis covers the ___ and the ___.
a. Tunica albuginea and testicular vein
b. Testicular vein and anus
c. Seminiferous tubules and epididymis
d. Tunica albuginea and spermatic cord

18. Possible complications with insertion of a penile implant can include ___.
a. Hemorrhaging
b. Vomiting
c. Dizziness
d. Limited mobility

19. The surgical team dipped their hands in a basin filled with ____.
a. Epinephrine
b. Hydrochloride
c. Isopropyl alcohol
d. Water

20. A penile implant can malfunction over time with ___ still working at 10 years.
a. 78 percent
b. 67 percent
c. 55 percent
d. 12 percent

Mass Casualty on Deck

1. **What part of the jet continued to stretch, causing the mass casualty on deck?**
   a. Tip of the wire
   b. Wire
   c. Wings
   d. None of the above

2. **What type of emergency amputation had to be performed?**
   a. Below the knee
   b. Above the knee
   c. Complete limb removal
   d. Foot only

3. **The patient was covered with a ___ after he was taken to the OR?**
   a. Gurney
   b. Gown
   c. Warm blankets
   d. Prep sheet

4. **If a power saw fails, what type of tool needs to be available for the procedure?**
   a. Gigli Saw
   b. Satterlee Bone Saw
   c. Both a and b
   d. Neither a nor b

5. **A ___ needs to be applied to the affected limb to reduce blood loss during surgery.**
   a. Pneumatic tourniquet
   b. Clamps
   c. Surgical gown
   d. Forced-Air warming blankets

6. **The U-drape is draped ___ to the thigh.**
   a. Supine
   b. Anterior
   c. Proximally
   d. Inferior

7. **The surgeon used a #10 knife blade to make a ___ incision above the distal femur.**
   a. Diamond-shaped
   b. U-shaped
   c. Lateral
   d. V-shaped

8. **The ___ muscle compartments are identified to create flaps for coverage of the femoral stump.**
   a. Posterior and anterior
   b. Posterior and inferior
   c. Lateral, inferior and posterior
   d. Posterior, lateral and anterior

9. **A drainage system prevents which condition from forming within the surgical wound.**
   a. Edema
   b. Infection
   c. Phantom pain
   d. Loss of blood

10. **Which condition is not listed as a complication of an amputation?**
    a. Pneumonia
    b. Heart failure
    c. Infection
    d. Dizziness

11. **Patients caring for the stump need to check for signs of infection that include ___.**
    a. Discharge
    b. Swelling
    c. Tender skin
    d. All of the above

12. **What was applied to the skin on the unaffected thigh?**
    a. Electrosurgical Unit
    b. Saline
    c. Dispersive electrode
    d. Tourniquet

13. **For a lower extremity, inflation time on a tourniquet at 300-350 mmHg should not exceed ___?**
    a. An hour
    b. One and a half hours
    c. Fifteen minutes
    d. Two hours

14. **The patient was placed in the ___ position for the procedure.**
    a. Supine
    b. Lateral
    c. Inferior
    d. Medial

15. **___ may play a large part in the sense of phantom pain.**
    a. Neuroplastic changes
    b. Magnetoencephalographic techniques
    c. Cerebral reorganization
    d. Existing medical issues

Increasing Airflow: The Process of Inferior Turbinate Reduction

1. **The primary symptom of turbinate hypertrophy is ___.**
   a. Congested breathing
   b. Infection
   c. Headaches
   d. Nose bleeds

2. **Turbinates are long, narrow, spongy bone shelves that protrude into the ___.**
   a. Throat
   b. Tongue
   c. Nasal cavity
   d. None of the above

3. **Empty nose syndrome is when too much of the ___ is removed.**
   a. Receptor tissue
   b. Nose hair
   c. Nasal cavity
   d. Skin

4. **The turbinates are vascular structures; therefore, the primary contraindication for turbinate reduction surgery is ___.**
   a. Coagulopathy
   b. Turbinectomies
   c. Therapy
   d. Sinus infections

5. **Surgeons preferring radio frequency coblation will prime the coblation ____ with a layer of saline gel.**
   a. Forceps
   b. Wand
   c. Scissors
   d. Blade

6. **The turbinate should not be reduced more than ___ to ensure it does not interfere with receptor feedback.**
   a. 30 percent
   b. 27 percent
   c. 55 percent
   d. 25 percent

7. **The ___ may be introduced to irrigate and debride the turbinate.**
   a. Cottonoids
   b. Suction tubes
   c. Microdebrider
   d. All of the above

8. **A surgeon performing an extramural excision will require an ___ to remove turbinate tissue.**
   a. Forceps
   b. Endoscopicbiter
   c. Coblation wand
   d. Suction tubing

9. **Which turbinate acts as a buffer to protect the sinuses from direct nasal airflow?**
   a. Superior
   b. Inferior
   c. Middle
   d. Left

10. **The patient may experience ___ for approximately seven to 14 days postoperatively.**
    a. Nasal drainage
    b. Swelling
    c. Dryness
    d. All of the above

Answers CE CREDIT PKG 13: 17.5 CONTINUING EDUCATION CREDITS

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a b c d	a b c d			Mark one box next to each number. Only one correct or best answer will be selected for each question.
1. ☐ ☐ ☐ ☐	7. ☐ ☐ ☐ ☐			
2. ☐ ☐ ☐ ☐	8. ☐ ☐ ☐ ☐			
3. ☐ ☐ ☐ ☐	9. ☐ ☐ ☐ ☐			
4. ☐ ☐ ☐ ☐	10. ☐ ☐ ☐ ☐			
5. ☐ ☐ ☐ ☐				
6. ☐ ☐ ☐ ☐				

Microbiology Review: Pathogens and Disease

a b c d	a b c d	a b c d	a b c d	Mark one box next to each number. Only one correct or best answer will be selected for each question.
1. ☐ ☐ ☐ ☐	7. ☐ ☐ ☐ ☐	13. ☐ ☐ ☐ ☐	19. ☐ ☐ ☐ ☐	
2. ☐ ☐ ☐ ☐	8. ☐ ☐ ☐ ☐	14. ☐ ☐ ☐ ☐	20. ☐ ☐ ☐ ☐	
3. ☐ ☐ ☐ ☐	9. ☐ ☐ ☐ ☐	15. ☐ ☐ ☐ ☐		
4. ☐ ☐ ☐ ☐	10. ☐ ☐ ☐ ☐	16. ☐ ☐ ☐ ☐		
5. ☐ ☐ ☐ ☐	11. ☐ ☐ ☐ ☐	17. ☐ ☐ ☐ ☐		
6. ☐ ☐ ☐ ☐	12. ☐ ☐ ☐ ☐	18. ☐ ☐ ☐ ☐		

Transmission-Based Isolation Precautions in the OR

a b c d	a b c d	a b c d	a b c d	Mark one box next to each number. Only one correct or best answer will be selected for each question.
1. ☐ ☐ ☐ ☐	7. ☐ ☐ ☐ ☐	13. ☐ ☐ ☐ ☐	19. ☐ ☐ ☐ ☐	
2. ☐ ☐ ☐ ☐	8. ☐ ☐ ☐ ☐	14. ☐ ☐ ☐ ☐	20. ☐ ☐ ☐ ☐	
3. ☐ ☐ ☐ ☐	9. ☐ ☐ ☐ ☐	15. ☐ ☐ ☐ ☐		
4. ☐ ☐ ☐ ☐	10. ☐ ☐ ☐ ☐	16. ☐ ☐ ☐ ☐		
5. ☐ ☐ ☐ ☐	11. ☐ ☐ ☐ ☐	17. ☐ ☐ ☐ ☐		
6. ☐ ☐ ☐ ☐	12. ☐ ☐ ☐ ☐	18. ☐ ☐ ☐ ☐		

Malignant Hyperthermia Crisis

a b c d	a b c d			
1. □ □ □ □	7. □ □ □ □			Mark one box next to each number. Only one correct or best answer will be selected for each question.
2. □ □ □ □	8. □ □ □ □			
3. □ □ □ □	9. □ □ □ □			
4. □ □ □ □	10. □ □ □ □			
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Surgery for Space Exploration

a b c d	a b c d	a b c d	a b c d	
1. □ □ □ □	7. □ □ □ □	13. □ □ □ □	19. □ □ □ □	Mark one box next to each number. Only one correct or best answer will be selected for each question.
2. □ □ □ □	8. □ □ □ □	14. □ □ □ □	20. □ □ □ □	
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6. □ □ □ □	12. □ □ □ □	18. □ □ □ □		

Cannulated Retinal Surgery

a b c d	a b c d			
1. □ □ □ □	7. □ □ □ □			Mark one box next to each number. Only one correct or best answer will be selected for each question.
2. □ □ □ □	8. □ □ □ □			
3. □ □ □ □	9. □ □ □ □			
4. □ □ □ □	10. □ □ □ □			
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Innovations in Endoscopic Sinus Surgery

a b c d	a b c d			
1. □ □ □ □	7. □ □ □ □			Mark one box next to each number. Only one correct or best answer will be selected for each question.
2. □ □ □ □	8. □ □ □ □			
3. □ □ □ □	9. □ □ □ □			
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6. □ □ □ □				

Automated Anesthesia and Natural Orifice Transluminal Endoscopic Surgery

a b c d	a b c d	a b c d	a b c d	
1. □ □ □ □	7. □ □ □ □	13. □ □ □ □	19. □ □ □ □	Mark one box next to each number. Only one correct or best answer will be selected for each question.
2. □ □ □ □	8. □ □ □ □	14. □ □ □ □	20. □ □ □ □	
3. □ □ □ □	9. □ □ □ □	15. □ □ □ □		
4. □ □ □ □	10. □ □ □ □	16. □ □ □ □		
5. □ □ □ □	11. □ □ □ □	17. □ □ □ □		
6. □ □ □ □	12. □ □ □ □	18. □ □ □ □		

Minimally Invasive Posterior Spinal Fusion

a b c d	a b c d			
1. □ □ □ □	7. □ □ □ □			Mark one box next to each number. Only one correct or best answer will be selected for each question.
2. □ □ □ □	8. □ □ □ □			
3. □ □ □ □	9. □ □ □ □			
4. □ □ □ □	10. □ □ □ □			
5. □ □ □ □				
6. □ □ □ □				

Exploring the Penile Prosthesis Procedure

a b c d	a b c d	a b c d	a b c d	
1. □ □ □ □	7. □ □ □ □	13. □ □ □ □	19. □ □ □ □	Mark one box next to each number. Only one correct or best answer will be selected for each question.
2. □ □ □ □	8. □ □ □ □	14. □ □ □ □	20. □ □ □ □	
3. □ □ □ □	9. □ □ □ □	15. □ □ □ □		
4. □ □ □ □	10. □ □ □ □	16. □ □ □ □		
5. □ □ □ □	11. □ □ □ □	17. □ □ □ □		
6. □ □ □ □	12. □ □ □ □	18. □ □ □ □		

Mass Casualty on Deck

a b c d	a b c d	a b c d		
1. □ □ □ □	7. □ □ □ □	13. □ □ □ □		Mark one box next to each number. Only one correct or best answer will be selected for each question.
2. □ □ □ □	8. □ □ □ □	14. □ □ □ □		
3. □ □ □ □	9. □ □ □ □	15. □ □ □ □		
4. □ □ □ □	10. □ □ □ □			
5. □ □ □ □	11. □ □ □ □			
6. □ □ □ □	12. □ □ □ □			

Increasing Airflow: The Process of Inferior Turbinate Reduction

a b c d	a b c d			
1. □ □ □ □	7. □ □ □ □			Mark one box next to each number. Only one correct or best answer will be selected for each question.
2. □ □ □ □	8. □ □ □ □			
3. □ □ □ □	9. □ □ □ □			
4. □ □ □ □	10. □ □ □ □			
5. □ □ □ □				
6. □ □ □ □				