CDC A4N151

Surgical Service Journeyman

Volume 2. Infection Control

Air Force Career Development Academy
The Air University
Air Education and Training Command

A4N151 02 1506, Edit Code 03
AFSC 4N151

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Material in this volume is reviewed annually for technical accuracy, adequacy, and currency. For SKT purposes the examinee should check the *Weighted Airman Promotion System Catalog* to determine the correct references to study.

This career development course (CDC) volume 2 focuses on some of the absolutely essential aspects of surgical care; those dealing with infection control. Without these measures, surgery would not be an effective therapeutic measure—we could fix an immediate problem, but the patient would probably die from infection later.

Unit 1 begins with a brief look at what infection control is trying to overcome—the numerous microorganisms that inhabit the surgical environment. Then we cover how these microorganisms cause infections and how the body responds to infection.

Unit 2 shifts the infection control emphasis from the inanimate to the animate—the infection control measures taken by surgical personnel. The unit begins with some of the infection control programs and functions in place in most Air Force medical facilities. The second section of the unit then connects infection control directly to personal hygiene, surgical attire, and sanitation/housekeeping practices.

Unit 3 covers what some consider as the key element to infection control—the cleaning and care involved in getting surgical instruments and supplies ready for sterilization. The unit opens with the initial cleaning and disinfection of used instruments and follows the instruments in sequence, discussing each step of the re-processing process. The second section of the unit covers how instruments and supplies are packaged before being subjected to a sterilization process.

Unit 4 deals with sterilization and disinfection. It starts by defining these processes, looks at the agents used, defines basic principles of disinfection, then moves to specific methods used to sterilize and disinfect patient care items. The bulk of the unit deals in-depth with the two most commonly used methods of sterilization: steam sterilization and chemical sterilization.

In the last unit, unit 5, the methods used to "quality control" the sterilization processes are discussed in detail. The first section covers the mechanical, chemical, and biological devices used to test the efficiency and effectiveness of the sterilizers. It also gives detailed instructions for making and using test packs. The second section focuses on handling and storing supplies after they are sterilized. The third and final section of this unit briefly looks at the rules of aseptic technique as they apply to sterile fields.

A glossary is included for your use.

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This volume is valued at 24 hours and 8 points.

NOTE:

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings and numbers. After reading the unit menu page and unit introduction, study the section, answer the self-test questions, and compare your answers with those given at the end of the unit. Then complete the unit review exercises.

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Unit 1. Microbiology and Infection

HISTORICALLY, INFECTION WAS A MAJOR OBSTACLE TO SURGERY. Although surgeons developed a great deal of skill, knowledge, and speed early in the practice of surgery, infections still caused many deaths. The key that opened the door to modern infection control procedures was man's understanding of the "invisible" creatures that cause disease. With the invention of the microscope and Louis Pasteur's discovery of the link between bacteria and disease in the 1800s, the door opened for development of antiseptics and sterile techniques.

The science that evolved around the study of these tiny organisms is called *microbiology*. Microbiology is the study of living organisms too small to see with the unaided human eye. These microorganisms include bacteria, viruses, fungi (yeasts and molds), and animal parasites (worms and protozoa).

Before you can understand the process of infection in the surgical environment, you need a basic knowledge of microbiology. This unit begins with identification and classification of common microorganisms and continues with a discussion of the infectious process.

1–1. Microorganisms and Surgical Personnel

As a member of the military healthcare team, you are at constant "war" with microscopic enemies that cause disease and infection. As in any war, you need to learn as much as possible about these enemies so you can exploit their weaknesses and defend against their strengths. You have many "weapons" at your disposal, but you must carefully choose which ones to use, and when to use them, in this ongoing battle.

This section helps prepare you for "battle." First, we introduce some general classifications of microorganisms, and then we look at some specific types of microorganisms of special concern to surgical personnel.

201. General characteristics of microorganisms

Microorganisms are minute living structures generally categorized as plants, animals, or viruses. Some organisms are called *parasites* because they rely on a living *host* organism to sustain their existence. Microorganisms that are found in soil, water, and debris and live off dead or decaying organic matter are called *saprophytes*. Some saprophytes, such as *Clostridium tetani* (the "bug" that causes tetanus or lockjaw), cannot live in healthy living tissue. Instead, they require dead (necrotic) tissue like that found in an old, untreated, wound to survive.

Microorganism classification

Microorganisms are classified in many ways, but for our purposes we will concentrate on whether they are pathogenic or non-pathogenic, and whether they are resident or transient.

Pathogenic microorganisms

When microorganisms grow in or on the tissue of another life form and cause damage or disease, they are called *pathogenic*. Pathogenic microorganisms can enter the human body through a break in the skin or through a body orifice or tract that links internal body structures to the outside environment.

They produce disease either because growth of the microorganism destroys surrounding tissue or because they produce toxins (poisons) which, in turn, cause disease. Pathogenic microorganisms include bacteria, viruses, fungi, molds, yeasts, rickettsia, and protozoa.

Nonpathogenic microorganisms

Not all microorganisms are pathogenic (disease-producing). There are millions of microorganisms on your skin, in your mouth and nose, in the air you breathe, in the water you drink, and on just about everything you come in contact with. Most of these *non-pathogenic* microorganisms are harmless, and many play vital roles in maintaining normal human body function and the delicate balances in nature as a whole. However, some organisms are nonpathogenic in their normal environment, but become pathogenic when introduced into another environment. For example, the bacteria *Escherichia coli* are normally found throughout the intestines, but can cause a severe abdominal infection when introduced into tissue outside the intestines.

Resident microorganisms

Resident microorganisms, or normal flora, live in the deep cracks and folds of the skin or in body orifices, such as the oral cavity or intestinal tract. As previously stated, many resident microorganisms are beneficial because they help maintain chemical balances within the body.

Transient microorganisms

Transient microorganisms have a very short life span and reside on the external surfaces of an object or live organism. The bacteria that grow and multiply on your skin and the microorganisms that can be found on the floor and walls of the operating room are examples of transient microorganisms.

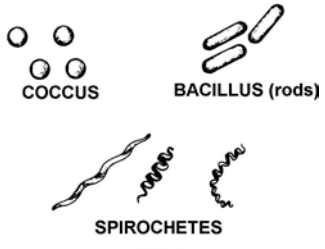
Identifying bacteria and viruses

Two types of pathogenic microorganisms are of most concern in the hospital environment—bacteria and viruses.

Bacteria

Bacteria are single-celled organisms that are members of the plant family. Bacterial classification is based on morphology (shape, arrangement, and internal structure), growth requirements, whether or not they form spores, and how they react to certain dyes used in laboratories to stain them.

Factors in Bacteria Classification

Factor	Description
Morphology	There are three principle shapes of bacteria (fig. 1–1): • Round or *cocci*. • Rod-shaped or *bacilli*. • Spiral-shaped or *spirilla*.  **Figure 1–1. Bacteria.** Bacteria are also identified by the arrangement the cells generally assume. They are commonly found as individual cells, in pairs, chains, or clusters. Microbiologists also classify bacteria by looking at the internal structure of the cells, a subject much too complicated to address in this text.

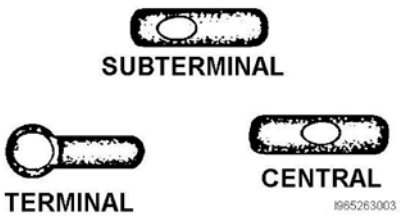
<table>
<tr><th colspan="3">Factors in Bacteria Classification</th></tr>
<tr><th>Factor</th><th colspan="2">Description</th></tr>
<tr><td rowspan="4">Growth requirements</td><td colspan="2">Because bacteria are living cells, certain conditions must be met before they can live, grow, and reproduce. For bacteria to survive, they must have proper nutrition, temperature, moisture, gas exchange, and acid-base balance.</td></tr>
<tr><td>Nutrition</td><td>Bacteria require a nutrition (food) source of organic or inorganic carbon. The pathogenic bacteria that cause most surgical infections are parasitic; they receive organic carbon from the living tissue in the human body.</td></tr>
<tr><td>Temperature and moisture</td><td>Bacteria also grow at specific temperatures; most thrive in an environment between 68° and 104° F (20° and 40° C). Most bacteria also thrive in moist environments. This makes the human body, with its 98.6° F (37° C) “normal” temperature, and its moisture laden tissues, an ideal incubator for many types of bacteria. While bacteria require moisture to grow, many types can survive, usually in a dormant state, in a dry environment.</td></tr>
<tr><td>Gas exchange</td><td>Bacteria are also classified by how they respond to oxygen.
Bacteria that grow only in the presence of oxygen are classified as strict aerobes (or obligate aerobes). The method used to test for and grow them is an aerobic culture.
Bacteria that grow only in an oxygen-free environment are classified as strict anaerobes (or obligate anaerobes).
Some bacteria can grow in either the presence or absence of oxygen; they are called facultative anaerobes.
The growth of the anaerobic bacteria generally depends on the presence of gases other than oxygen. For example, some bacteria grow best in an atmosphere containing a high concentration of hydrogen, while others grow best in a high concentration of nitrogen. Any culture that incubates in an atmosphere lacking oxygen is called an anaerobic culture.</td></tr>
<tr><td>Acid-base balance (pH)</td><td>The proper pH must be maintained in order for bacteria to survive. Most bacteria grow best in a neutral (pH 7.0) or slightly alkaline environment (pH slightly above 7.0). Many of the detergent-germicides used in the operating room contain acids or bases to intensify their bactericidal actions.</td></tr>
<tr><td>Spore-forming bacteria</td><td colspan="2">Most bacteria are active and continuously carry out basic life functions, such as growth, reproduction, and movement. These active-state bacteria are called vegetative bacteria. Some types of bacteria, particularly certain rod-shaped bacteria (bacilli), however, form spores.
Spores are inactive, round, dry, thick-walled bodies found within bacterial cells. As shown in figure 1–2, the spore may form in the center, off-center, or at the end of the rod-shaped cell. When a bacterial cell forms a spore and becomes inactive, it is referred to as a dormant cell. The spore contains enough genetic material to make it capable of developing into a living, vegetative bacterial cell. Just like a bear in the winter, the bacterial cell goes into a kind of “hibernation” to protect itself from being destroyed when environmental conditions are unfavorable. In this dormant state, which may last for several years, the cell survives without the normal conditions needed for growth. When favorable environmental conditions return, the bacterial cell comes out of its dormant state and, like the bear in spring, resumes its normal life functions. Bacterial spores are the most destruction-resistant form of microorganism. They are widely distributed in nature and commonly found in soil, dust, and water. Spores are far more resistant to germicidal solutions and temperature extremes than vegetative bacteria.
 

Figure 1–2. Bacillus spores.</td></tr>
</table>

Factors in Bacteria Classification	
Factor	**Description**
Bacterial staining	Because they are small and transparent, bacteria are difficult to see under a microscope. Staining the bacterial cells with certain dyes makes them stand out from background material. The Gram stain is the most common type used in clinical laboratories to aid in identifying bacterial cells. • Bacteria that absorb the special purple dye (stain) and resist subsequent de-coloration are called Gram-positive bacteria. • Those that do not retain the dye and become de-colored are referred to as Gram-negative bacteria. You will hear these terms used to describe bacteria, and they are also used to help determine the most effective antibiotic to use against the bacteria.

Viruses

Viruses are much smaller than bacteria; they can only be seen using electron microscopes. They come in many shapes and are so small they can pass through bacterial filters. *All viruses are parasites and multiply only within living cells*. Viruses are found in surgical soil, on the surfaces of soiled objects (fomites), or in the air. *A virus cannot multiply until it has invaded susceptible tissue cells.* Viruses are highly selective in their growth requirements. Some viruses grow in nerve tissue cells (encephalitis and polio), some grow in the liver (hepatitis), and others grow in the tissue of the respiratory tract (common cold and influenza). Viruses can be spread from person-to-person, insect- or animal-to-person, or from contaminated items-to-person.

202. Pathogenic microorganisms in the surgical environment

Many pathogenic microorganisms are present in the hospital and surgical environment. To better understand infection control activities in the operating room and sterile processing, you should become familiar with some of the more common "bugs" that cause infections and disease. The table below and the paragraphs which follow describe some common pathogens and the diseases or infections they are associated with.

Microorganism		Commonly Found In (On)	Infection or Disease
1. Staphylococci (non-spore-forming bacteria)	Staphylococcus aureus	Skin Hair Respiratory tract Urinary tract	Wound infection Boils (skin infections) Pneumonia Urinary tract infection Enterocolitis Septicemia
2. Streptococci (non-spore-forming bacteria)	Streptococcus pyogenes	Nose Nasopharynx	Wound infection Cellulitis Urinary tract infection
	Streptococcus pneumoniae (pneumococci)	Nose Nasopharynx Oropharynx	Lobar pneumonia Sinusitis Parotitis Conjunctivitis Peritonitis
	Streptococcus viridans	Upper respiratory tract Intestinal tract	Localized gum/mouth sores abdominal abscess pulmonary abscess

Microorganism		Commonly Found In (On)	Infection or Disease
3. Neisseria (non-spore-forming bacteria)	Neisseria gonorrhoeae (gonococci)	Genitourinary tract Rectum Mouth Eye	Gonorrhea Gonorrheal vulvovaginitis Pelvic inflammatory disease Conjunctivitis
	Neisseria meningitidis (meningococci)	Nose Oropharynx	Meningitis Pneumonia
4. Enteric (coliform) (non-spore-forming bacteria)	Salmonella typhosa	Intestinal tract	Typhoid fever
	Shigella sonnei		Dysentery
	Salmonella (others)		Enteric fever Gastroenteritis Septicemia
	Escherichia coli	Large intestine Perineum	Peritonitis
	Proteus vulgaris	Intestinal tract	Cystitis
	Pseudomonas aeruginosa	Soil Skin Intestinal tract	Wound infection Urinary tract infection Burn infection
5. Clostridium (spore-forming bacteria)	Clostridium tetani	Soil Dust Feces	Tetanus (Lockjaw) Surgical tetanus
	Clostridium perfringens	Soil	Gas gangrene
6. Mycobacterium tuberculosis (non-spore-forming bacteria)		Respiratory tract Urine Lymph nodes	Tuberculosis Peritonitis Meningitis Infection of almost any tissue, including: skin, bones, kidney, lymph nodes, and fallopian tubes
7. Viruses	Rhinoviruses and influenza viruses	Respiratory tract	Colds Flu
	Hepatitis A	Blood and urine from infected persons Sewage/contaminated water Contaminated shellfish Food handled by infected person practicing poor hygiene	Infectious hepatitis
	Hepatitis B	Blood Saliva Other body fluids Feces	Serum hepatitis
	Hepatitis C	Blood Blood products	Non-A, non-B, transfusion associated hepatitis

Microorganism		Commonly Found In (On)	Infection or Disease
	Hepatitis D	Co-exists with Hepatitis B in some patients	Superinfects liver, leads to necrotizing liver disease and death
	Hepatitis E	Typically spread by fecally contaminated acute water.	Viral hepatitis
	Herpes virus	Lesions and body fluids of infected patients	Localized eruptions on borders of lips, in mouth, in nose (cold sores). Localized eruptions on genitalia or anal region. Conjunctivitis Meningoencephalitis
	Human immunodeficiency virus (HIV)	Blood Semen Other body fluids	Acquired Immunodeficiency Syndrome (AIDS)

As you can see from the table above, there are numerous microorganisms capable of causing infectious complications in surgical patients. In the following paragraphs, we briefly discuss the major groupings, some of the types of infections or diseases they cause, and how we attempt to control them in the surgical arena.

Pyogenic bacteria

We call bacteria that cause wound infections *pyogens*. These bacteria cause wound inflammation that leads to pus-forming (*suppurative*) infections. If the bacterial growth is not stopped at the wound or entry site, the infection can spread to the blood stream and then to other parts of the body. Pyogenic bacteria include most coccal (sphere-shaped) bacteria, and the enteric, or coliform, bacteria.

Staphylococci

This group of bacteria is responsible for a variety of infections, commonly called “staph” infections—the most common type of postoperative wound infections. Many staphylococcal wound infections start as relatively simple skin and mucous membrane inflammation (localized abscesses and pustules), but spread via the vascular system causing serious infections of the lungs (pneumonia), urinary tract, nerve tissue (meningitis), and bones (osteomyelitis). They are non-spore-forming, facultative anaerobes (they grow with or without oxygen), and are commonly found on the surface of the skin and mucous membranes of the nose and throat.

Sometimes hospital personnel are staphylococci carriers. As previously mentioned; these bacteria are carried on the skin and continually “shed” into the surrounding environment. This shedding of staphylococcal bacteria not only contaminates clothing worn by the carrier, but also leads to dispersal within the environment; thereby increasing the risk of wound contamination. The main purpose for wearing surgical scrub suits, hats, hoods, masks, and shoe covers is to minimize the dispersal of bacteria through carrier shedding.

Streptococci

These microorganisms cause such diseases as septic sore throat (“strep” throat), scarlet fever, impetigo, bacterial endocarditis, rheumatic fever, neonatal meningitis, and pulmonary infections such as lobar pneumonia. These infections often appear as watery, blood-stained abscesses. “Strep” infections are often more harmful to the human body than staphylococci because the streptococcal bacteria usually cause widespread tissue damage without localized infection. Like staphylococci, most streptococci are non-spore-forming, facultative anaerobes.

There are three types of streptococci that are of particular concern to hospital personnel because of their ability to cause severe infections and diseases—the *Streptococcus pyogenes* group, *Streptococcus pneumoniae* (diplococci or pneumococci), and the *Streptococcus viridans* group.

Streptococci are spread via direct contact or inhalation of air containing bacterially contaminated moisture droplets and dust. Since many strains of streptococci are carried in the upper respiratory tract, they are easily transmitted when the infected person sneezes, coughs, talks, or laughs. Spread of streptococcal bacteria is prevented by using strict aseptic technique, proper handling and frequent changing of surgical masks, good room ventilation, and by excluding personnel with upper respiratory infections from direct patient contact.

Neisseria gonorrhoeae (Gonococci)

Gonococcal (*Neisseria gonorrhoeae*) microorganisms cause the sexually transmitted disease gonorrhea by invading the mucous membranes of the genitourinary tract. Gonococci also cause conjunctivitis of the eyes when transferred from the perineum. Long-term gonococcal infection spreads to the reproductive system and causes sterility. When gonococci enter the circulatory system, severe septicemia may result. *Neisseria gonorrhoeae* may also infect the eyes of newborn infants during passage through the birth canal; if untreated, it can result in permanent blindness. Gonorrhea is usually transmitted by direct sexual contact, but may be transmitted by contact with bedding, clothing, and other contaminated items. Control of this disease is accomplished through stringent sanitation methods and drug therapy for infected persons.

Neisseria meningitidis (Meningococci)

Meningococci are normally found in the nasopharynx, but may cause meningitis in people who are susceptible to the disease. It may be fatal, particularly when the patient is a child. It is transmitted primarily through droplet inhalation or from direct contact with the source. Meningitis can cause an epidemic when many people are crowded together in confined spaces.

Enteric (coliform) bacilli

Enteric bacilli are non-spore-forming, facultative anaerobes normally found in the intestinal tracts of humans and animals. Normally, enteric bacilli are harmless—as long as they remain in their normal habitat. When introduced into other areas of the body, they can cause severe suppurative infections. For example, when an inflamed appendix ruptures, fecal material containing enteric bacilli is introduced into the abdominal cavity; these bacilli can cause severe peritonitis. Enteric bacilli that migrate from the perineal region are a common cause of urinary tract infections. Three of the more common types of enteric bacilli are *Escherichia coli (E. coli)*, *Proteus mirabilis*, and *Proteus vulgaris*. *Escherichia coli* are, by far, the most common enteric bacillus found in the intestinal tract. *Proteus mirabilis* and *P. vulgaris* are primarily found free-living in water, soil, and sewage, but are also frequently found in fecal specimens from healthy individuals.

Another enteric bacillus is *Pseudomonas aeruginosa*. This aerobic bacterium is commonly found in soil, water, sewage, and air. Occasionally, it is also found on the skin or in the intestinal tract. It was once thought to be non-pathogenic, but is now considered a pathogen—when it is introduced into an area with no normal defenses. Pseudomonas is often present in mixed bacteriological infections, and also attacks the tissues of debilitated persons (particularly burn victims).

Anaerobic bacteria

The anaerobic (grow without oxygen) bacteria most commonly encountered are the *clostridia*. *Clostridia* are spore-forming bacilli, the most difficult type of bacteria to destroy. Fortunately, most spore-forming bacteria are nonpathogenic, but some strains of *Clostridia* produce potent toxins and are pathogenic. *Clostridia* are always present in soil and in the intestinal tracts of humans and animals; they help decompose organic matter. When introduced into a surgical wound however, severe infections develop. Two types of *Clostridia* that cause severe wound infections are *Clostridium tetani* and *Clostridium perfringens (welchii).*

Clostridium tetani

When introduced into a wound, *Clostridium tetani* causes the disease known as tetanus or "lockjaw." This disease follows the introduction of tetanus spores (from soil or feces) into puncture wounds, burns, surgical sutures, or traumatic injuries. If anaerobic conditions exist in the wound, *Clostridium tetani* spores return to their vegetative state and begin secreting a powerful toxin. This toxin attacks the tissue of the spinal cord and peripheral motor nerve endings. The damaged nerve tissue causes muscle spasms near the infection site and in the muscles of the neck and jaw; hence the name "lockjaw." As the disease spreads, the spasms become more widespread and severe, resulting in convulsions and eventual death. *Surgical tetanus* can occur postoperatively as the result of improperly sterilized instruments or dressing materials. Tetanus is controlled by injection of antitoxin and active immunization programs. As a healthcare worker, you are required to be immunized against *Clostridium tetani*.

Clostridium perfringens (welchii)

This bacteria causes a severe infection of muscle tissue, commonly referred to as *gas gangrene* (properly known as *clostridial myonecrosis*). Gas gangrene may be a complication of severe traumatic injuries. Lacerated wounds exposed to soil and accompanied by a compound bone fracture are particularly susceptible. In this type of injury, the blood supply to the muscle tissue near the injury may be damaged or destroyed, which causes tissue necrosis (tissue death). This dead and dying tissue, rich in bacterial nutrients, provides an ideal anaerobic environment for *clostridial* spores, transferred from the soil, to grow and multiply. As the bacteria multiply, they secrete powerful toxins and enzymes that destroy the surrounding tissue. They also produce gas as the result of metabolizing tissue carbohydrates. The absorption of the gas results in further tissue death, providing continuous nutrition for *Clostridium perfringens* to thrive on. Infections caused by *clostridia* are usually mixed infections involving the presence of other types of anaerobic bacteria, not just *Clostridium perfringens* alone.

Mycobacterium tuberculosis

This bacterium is an aerobic, non-spore-forming bacillus (rod-shaped bacteria). It has a wax-like protective coating surrounding the cell which makes tubercle bacilli nearly as hard to destroy as the spore-forming bacteria. *Mycobacterium tuberculosis* is responsible for causing the disease tuberculosis (TB), which can infect virtually every tissue in the body. The bacterium is spread through the lymphatic and vascular systems, and causes dense nodules or tubercles to form in the tissue it infects. Even though most deaths caused by TB stem from infection of the lungs, the tubercle bacillus can cause infections in bone, joints, lymph nodes, spleen, liver, kidneys, and the gastrointestinal tract. This microorganism is transmitted primarily by inhalation of contaminated dust or droplets discharged by the infected person through sneezing, coughing, or kissing. Effective infection control for TB includes rigid housekeeping, immediate sterilization or disinfection of contaminated items, and strict isolation of individuals with active forms of the disease.

Viruses

Viruses are responsible for many of the most common infectious diseases. Viruses are parasites that attack specific types of living cells. They reproduce by taking over the host cell and causing it to reproduce more viruses. Viral diseases are caused by the rearrangement or modification of normal cell functions in an infected person. You may have had, or been immunized against, many viral diseases often referred to as childhood diseases. Many viral diseases are controlled through immunization programs, but others pose serious health problems for society and are of special concern to hospital personnel. Viruses of most concern in the hospital environment include rhinoviruses, influenza viruses, hepatitis viruses, herpes viruses, and one of the most notorious viruses of all, the human immunodeficiency virus (HIV) that causes acquired immunodeficiency syndrome (AIDS).

Rhinoviruses and influenza viruses

The diseases we call the "common cold" are caused by numerous *rhinoviruses*. The *rhinoviruses* primarily attack the respiratory system and can cause severe inflammation of the nose and throat. Young children are particularly susceptible to "colds" caused by these viruses, and pneumonia is always a possible complication.

Influenza viruses not only affect the respiratory system, but can affect other body systems (particularly the gastrointestinal system). Chills, fever, body and joint aches, swollen glands, and general malaise characterize diseases caused by *influenza viruses*. Recovery is slower than with *rhinoviruses* and because of the body's weakened state bacterial pneumonia can easily develop.

Because there are numerous types of *rhinoviruses* and *influenza viruses*, it is impossible to develop vaccines to inoculate against all of them. The "flu shot" you get every year is intended to inoculate you from the *influenza* strains epidemiologists believe will be most virulent during the season; *it does not protect you from all forms of influenza.* Surgical patients are particularly susceptible to viral infections because their bodies are already weakened by disease or injury. The trauma caused by surgery weakens their natural defense mechanisms and allows infection by "cold" or "flu" viruses to cause numerous complications.

Besides being highly virulent to patients with weakened immune systems, *rhinoviruses* and *influenza viruses* are highly contagious and easily transmitted from person to person. Even in the operating room where you constantly wear clean surgical masks, these viruses are easily spread via aerosol droplets that blow through the masks when you sneeze, cough, talk, or laugh. The viruses contaminate sterile setups and find their way into open wounds. Other surgical team members breathe the contaminated air and become infected. As a result, not only are patients infected, but a mini epidemic results among surgical personnel. Overall patient care suffers because there are fewer healthy staff members to provide direct patient care. Also, those infected personnel who remain on duty perform at less than peak proficiency because they simply do not feel well.

The best way to combat *rhinoviruses* and *influenza viruses* is to keep healthy. If you do come down with a cold or the flu, report it to your supervisor so you can go to sick call and be kept away from direct patient care activities. A simple cold or case of the flu that a healthy person would recover from in a few days can do serious harm to, and potentially kill, a surgical patient. Being a "martyr" and trying to work with surgical patients when you have a viral infection does more harm than good.

Hepatitis viruses

The *hepatitis viruses* specifically attack the liver and cause reactions ranging from slight jaundice with a full recovery to complete destruction of liver tissue resulting in death. We used to believe there were only two types of *hepatitis virus*, type A and type B. We now know there are many hepatitis viruses, including type C (formerly called non-A, non-B), type D (the delta agent), and type E (enteric). As researchers continue their investigations of viral diseases, other types may be discovered.

Hepatitis (types A and E) causes symptoms commonly known as infectious hepatitis. This type of hepatitis is usually transmitted by ingestion. Contaminated food, milk, and shellfish infected by sewage-polluted waters are common sources of the A virus. Contaminated water is the primary source of the E virus. Type A and type E hepatitis is found worldwide, and is particularly prevalent in countries with poor sanitation. Symptoms include fever, nausea, gastrointestinal upset, liver enlargement and tenderness, and jaundice. The disease caused by type A usually lasts from three to eight weeks (sometimes longer) and is seldom fatal. Type E hepatitis is not fully understood, but appears particularly lethal for pregnant women. A short-term vaccine is available to protect against Hepatitis A from three to six months; you may receive it if you are being deployed to a high-risk area.

Hepatitis (types B, C, and D) causes diseases commonly known as *serum hepatitis*; they are transmitted solely by contact with infected blood or body fluids. The symptoms are similar to those of

infectious hepatitis, but the disease is more prolonged and more likely to cause permanent damage or death. Type B hepatitis primarily affects young adults in high-risk groups (such as surgical personnel); adults generally recover, but the disease is usually fatal in infected newborns. Type D hepatitis is found only in combination with type B; it intensifies the effects of the disease and is the type most likely to result in death. Type C accounts for as much as 90 percent of hepatitis found in post-transfusion patients.

Serum hepatitis is of special concern to surgical personnel because of the frequent exposure to blood and body fluids, combined with the inherent risks presented by the numerous sharp instruments used in surgery. Because even 0.0001 ml of blood can transmit the infection, even a scratch from an infected instrument can result in the disease. This is why it is imperative for surgical personnel to be immunized with the hepatitis B vaccine (the vaccine also immunizes you against type D). *The vaccine is mandatory for all military healthcare workers.* The risk of transmission is also one reason you must immediately report all needle sticks or wounds received on duty to your supervisor. You should be tested for hepatitis after any sharp instrument injury or other exposure to blood or body fluids.

Herpes viruses

There are many diseases caused by different strains of *herpes viruses* including cold sores, chicken pox in children, and shingles (painful nerve disease) in adults. The types of *herpes virus* we are most concerned with in the operating room is *Herpesvirus hominis,* the virus that causes cold sores, fever blisters, genital sores, and inflammation of the cornea of the eye (disease conditions collectively known as *herpes simplex*). This highly contagious virus is usually transmitted through direct intimate contact with infected persons or contact with virally contaminated items. If you adhere to strict standards of aseptic technique and use stringent environmental housekeeping on cases involving patients infected with herpes, transmission of this virus should be effectively controlled. Usually, a special effort is made to alert all surgical team members to any patients afflicted with contagious diseases, such as *herpes simplex,* to ensure all necessary precautions are taken to reduce the risk of cross-contamination.

Human immunodeficiency virus

One of the most widely publicized, life-threatening, and incurable disease-causing viruses is HIV. It is the virus that causes AIDS. This virus poses a serious occupational health risk to medical personnel.

HIV is transmitted by exposure to infected blood, blood components, or other body fluids; primarily those that contain white blood cells. The virus has been found in blood, semen, vaginal secretions, saliva, tears, breast milk, cerebro-spinal fluid, synovial fluid, pleural fluid, pericardial fluid, peritoneal fluid, amniotic fluid, and urine. *The virus may be spread by unprotected contact with any of these fluids, but is* ***NOT*** *spread by casual contact with an infected person.*

The HIV virus may remain dormant for 10 years—maybe even longer—before any symptoms of infection develop. When the HIV virus develops into AIDS, it virtually destroys the body's immune system. This makes the body susceptible to nearly all diseases or pathogenic agents. Death is inevitable and results from complications associated with numerous diseases occurring simultaneously.

All healthcare workers who handle or are exposed to blood and body fluids run a significantly greater risk of being infected than the average person. As a result of this increased risk, the Centers for Disease Control and Prevention (CDC) recommend healthcare workers consider *all* patients as potentially infected with HIV. It also recommends healthcare workers take standard (universal) precautions with all patients. The Occupational Safety and Health Administration (OSHA) issued the standard *Occupational Exposure to Bloodborne Pathogens; Final Rule.* This standard requires employers and employees at risk of exposure to follow certain rules and wear certain attire. We discussed some of these rules and precautions, and will cover more of them in the following sections.

You can see we have many microscopic “enemies” to attack and defend against in our battle with disease and infection. The next section looks at how these microorganisms attack, and how our bodies try to defend against them. Before moving on, answer the following questions to ensure you “know your enemy.”

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

201. General characteristics of microorganisms

1. What is the difference between organisms that are *parasites* and those that are *saprophytes*?

2. What is the general classification term used to describe microorganisms that cause tissue damage or disease?

3. What might happen if a normally harmless, nonpathogenic microorganism is introduced into an environment different from its normal habitat?

4. What is a resident microorganism?

5. What is a transient microorganism?

6. What are the two types of pathogenic microorganisms of most concern in hospitals?

7. Describe the three principle bacterial shapes.

8. What temperature range do most bacteria thrive in?

9. Do most bacteria prefer a moist or dry environment?

10. Name three categories that bacteria can be classified into on the basis of oxygen response.

11. What acid-base range do most bacteria grow best in?

12. Describe a bacterial spore.

13. Describe the size of viruses relative to bacteria.

202. Pathogenic microorganisms in the surgical environment

1. What are *pyogens*?

2. What group of bacteria causes the most common type of postoperative wound infection?

3. List some of the diseases caused by *streptococci.*

4. What diseases and infections are caused by *Gonococci*?

5. How is meningitis transmitted primarily?

6. Which *enteric bacilli* is the most prevalent in the intestinal tract?

7. What type of bacteria are the most difficult to destroy?

8. Name two spore-forming bacteria and the diseases they cause.

9. What makes the tubercle bacilli nearly as difficult to destroy as spore-forming bacteria?

10. Which viruses are responsible for causing the “common cold?”

11. What should you do if you think you have a cold or the flu? Why is this action necessary?

12. List the viruses that cause liver disease, and the specific diseases they cause.

13. Which of the viruses identified in question 12 are primarily transmitted by contact with infected blood or body fluids?

14. What highly contagious virus causes cold sores and fever blisters?

15. Which virus causes AIDS?

16. How is AIDS spread from person to person, and what effect does the disease have on the body?

1–2. The Infectious Process

In the previous section, we focused on the characteristics of microorganisms; then looked at some pathogenic bacteria and viruses of concern in the surgical environment. Fortunately, most individuals have active immune systems and defense mechanisms that help destroy or inhibit the growth of pathogenic microorganisms. As long as the body is healthy, many harmful organisms are powerless to penetrate its defenses. However, once the defenses are broken down because of an open wound, or because of lowered resistance following major trauma, the stage is set for entry and growth of pathogenic microorganisms. We discuss the process of infection and body defense mechanisms later in this unit, but first, we look at how these organisms enter the body and begin the disease or infection process.

203. The infection chain

Transmission of pathogenic microorganisms and the subsequent development of infections are often called “the chain of infection” (fig. 1–3). The links in this chain include the following:

- An infectious agent (pathologic microorganism).
- A reservoir, or place the infectious agent can multiply or grow.
- A portal of exit from the reservoir.
- A mode of infectious agent transmission.
- A portal of entry into the body.
- A host or person susceptible to the pathogenic organism.

These links must form a continuous cycle for infection to develop and/or spread. Keep this cycle in mind as we discuss the characteristics of each link and show how each link interacts in the disease process.

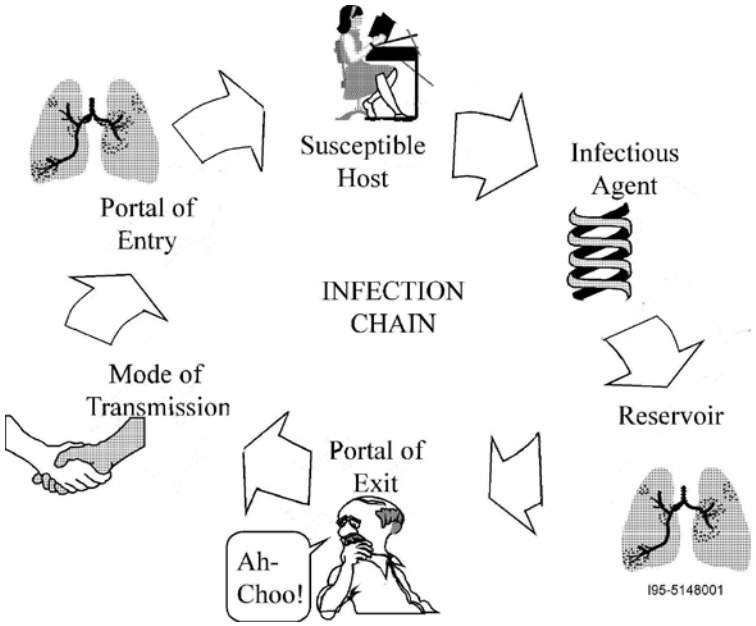


Figure 1–3. The chain of infection.

Infectious agent

The infectious agent is usually one of the microorganisms we discussed in the previous section. It may be a single type of microorganism, or more than one microorganism may "team-up" to form a mixed infection.

Reservoir

The human body is one of the most common breeding grounds and is a reservoir of infectious agents. Every individual has a host of different microorganisms growing in and on his or her body. You should recall that microorganisms normally residing on or in certain body areas are called resident microorganisms, or *normal flora*. These microorganisms are the largest source of potentially infectious agents in the hospital. For example, some *staphylococci* are normal flora of the skin and hair; many people carry them with no adverse effects. These "carriers" are walking sources of contamination because the bacteria residing on their skin and hair shed into the environment and contact items in the area. When these microorganisms enter an open wound, they become pathogenic.

In addition to skin and hair, the various orifices of the body are possible sources of infectious agents. The upper respiratory tract (nose and throat) harbors numerous microorganisms. In fact, the nasal and oral cavities are sometimes considered the "dirtiest" areas of the body. Organisms, such as *staphylococci*, *streptococci*, and *neisseria*, are normal flora in the nose and throat. This is one reason you must change your mask frequently! The gastrointestinal tract and perineal region are sources of various *enteric bacilli*, *staphylococci*, *streptococci*, and *clostridia*. The vaginal orifice in adult females commonly harbors *staphylococci*, *streptococci*, yeasts, and a variety of other potentially pathogenic microorganisms. Usually, organisms that are considered normal flora for healthy persons *do not* cause infections unless the immune system is weakened or the organisms are introduced into areas outside their normal habitat.

Additional reservoirs of contamination are infected substances from other people. Examples include sputum, feces, infected blood and blood components, pus from wounds, vaginal secretions, semen, and other bodily excretions or secretions. We touched on this when we discussed specific bacteria and viruses. For instance, you should recall that the hepatitis B virus and HIV are transmitted by contact with infected blood or blood components, and several other microorganisms are transmitted as airborne droplets exhaled through the nose and mouth.

Potentially infectious microorganisms can also come from *fomites*. We mentioned this word before, but we will formally define it to make sure you know what it means. A *fomite* is defined as any *inanimate* object or substance capable of harboring and transmitting a disease. Common fomites in surgery include such things as contaminated surgical instruments, environmental surfaces, linens, trash, drugs, and solutions. Fomites providing the best breeding grounds for microorganisms are moist, rather than dry (remember bacteria like moist environments). Examples of moist fomites in surgery include used anesthesia tubing, masks and breathing bags, soiled surgical masks, blood-soaked sponges, suction containers, and soiled linen from the operating room (OR) table.

Portal of exit

The most dangerous aspect of infectious agents is *not the disease* they can cause, but rather that the disease can be communicated from one person to another. Infectious agents act by invading, multiplying, causing disease in one reservoir, and then moving on to another. Most of this activity takes place inside a *host* (discussed later). The infectious agent must first find a way to leave that reservoir (carrier host) before it can be transmitted to another host. This is called the *portal of exit*, and it is the next link in the infection chain.

The portal of exit from a human carrier is usually related to elimination of some waste product (urine, feces, oral-nasal secretions, and genital secretions). The most common exit portals are the mouth, nose, anus, urethral meatus, and, occasionally, the eyes. Of particular concern to us are the infectious agents that exit the body in blood and the drainage of wounds.

Mode of transmission

The four major delivery methods of disease transmission include contact, vehicle or common source, airborne, and vector. In the table below we discuss each method and provide examples of how these methods of transmission are prevented in the operating room.

Disease Transmission Modes			
Route		**Description**	**Prevention**
Contact	Direct contact	Direct contact is simply what it says—the susceptible host directly touches or otherwise contacts an infectious organism. For example, you have a direct contact transmission if you have a cut on your finger, do not wear gloves, and touch drainage from a pus-filled wound with the cut finger.	Strictly following aseptic technique and by washing your hands frequently—particularly after directly touching a patient.
	Indirect contact	Contact with pathogenic microorganisms through intermediate contaminated objects is considered indirect contact—e.g., handling a contaminated instrument with your bare hands, then failing to wash them before you touch another patient. Here, you are transmitting microorganisms from one patient to another via your contaminated hands (intermediate object).	Follow the guidelines for preventing direct contact transmission.
	Droplet contact	Microorganisms are easily transmitted via aerosol droplets discharged from the nose and mouth when you sneeze, cough, talk, or laugh. Aerosol transmission can also occur when you hand wash soiled instruments or if you ultrasonically clean contaminated items (particularly if the lid of the cleaner is open).	• Frequently changing surgical mask. • Keeping talk to a minimum. • Keeping personnel with respiratory infections out of the operating room. • Avoid hand cleaning of instruments and decontaminate items before using ultrasonic cleaning.

Disease Transmission Modes		
Route	**Description**	**Prevention**
		• Protective attire must be worn if hand cleaning of contaminated instruments is unavoidable.
Vehicle	When infectious microorganisms are spread by ingestion of foods contaminated during preparation, it is called the vehicle route or common source transmission. Outbreaks of food poisoning traced to a specific restaurant or employee is an example of this type of transmission. Infection can also be spread via contaminated fluids such as those used for injection or irrigation in the hospital. If an open solution bottle or drug vial is used on several patients instead of being disposed of after single-patient use, common source transmission of contamination may occur.	• Always thoroughly wash your hands, especially before eating. • Rigidly apply all asepsis standards when handling all parenteral or topical solutions. • Inspect drugs and solutions for signs of contamination before use.
Airborne	Bacteria can live for long periods of time on dry surfaces, particularly if they are spore-forming. When contaminated aerosol droplets, discharged from a person's respiratory tract, evaporate, they leave behind an invisible, dry, dust-like residue. The same is true for "dust" formed from dried blood and pus. This dust acts as an airborne carrier of bacteria and can settle anywhere in the hospital. Air currents can "blow" these organisms into a susceptible host, where favorable growth conditions exist, and the infection begins.	• Effective, positive-pressure ventilation systems. • Frequent damp dusting of environmental surfaces with germicidal solutions. • Avoiding excessive movement in the OR. • Sealing trash and soiled linen in plastic bags or other sealed containers. • Bi-valving orthopedic casts outside the OR.
Vector	A vector is any live carrier, especially a rodent or insect, which transfers an infectious agent from one host to another. Insects, in particular, pose serious problems in the operating room because they are small enough to get inside the wrappers on sterile items; thereby contaminating the contents. Small flying or crawling insects can contaminate a sterile field and be unnoticed. When you see a group of OR people close all doors to a room and start madly swinging towels at a fly, they are trying to prevent transmission via the vector route.	Live plants are not allowed in the surgical suite, and food storage is restricted to specific areas, such as a refrigerator in the staff lounge (not your locker!).

As you can see from the examples, the best prevention is strict adherence to the rules of surgical asepsis.

Portal of entry

The portal of entry is the way the infectious agents enter the body. Portals of entry include the mouth and nose (most common), eyes, genital openings, anus, and the one we think of most often in surgery, breaks in the skin from incisions or other invasive procedures. These portals are usually specific for each microorganism. Organisms that are normal flora for one part of the body, for example, will not cause an infection unless they pass through a different entry portal to another part of the body. Generally speaking, a portal of entry is a link in the infection chain only if it allows an infectious agent to penetrate an area of the body where there is a favorable environment for that particular organism to become pathogenic.

For instance, microorganisms that cause gastroenteritis usually originate in the intestinal tract of a carrier and exit via feces. The susceptible host contacts the microorganisms, usually by touching the contaminated area with his or her hands, and the microorganisms enter the new host through the mouth when eating. If the host had washed his or her hands, the contact would have been restricted to the hands, conditions would be unfavorable for growth, and infection would not occur.

Susceptible host

The last link in the infection chain is a susceptible host. This is the individual whose body has been penetrated by the infectious agent and in whom a disease condition develops. This individual is *susceptible* or prone to, the infection when the body's defense mechanisms (we discuss these in the next section) cannot overcome the disease-producing microorganisms. Some of the factors that influence whether a surgical patient becomes a susceptible host include the type and number of microorganisms, the physical condition of the patient, and the type and techniques of surgery.

Type and number of microorganisms

Some microorganisms are more virulent than others, or are better adapted to resist the body's defense systems. When a type of bacteria that is normal flora in one part of the body invades an area where it is not normally found, it proliferates because resistance in the new area is either minimal or nonexistent. In an example we used in the last section, if a patient's appendix ruptures, fecal material containing *enteric bacilli* (non-pathogenic while in the intestines), enters the abdominal cavity. The abdominal cavity is not designed to defend against this type of bacteria, so peritonitis can develop.

When we discussed specific bacteria, we mentioned some that produce powerful toxins or poisons. If a wound is infected with bacteria that secrete harmful toxins, not only can tissue in the immediate wound area be damaged but the toxin can also be transported to other areas of the body. This damages tissues far away from the original entry point.

Antibiotic-resistant microorganisms are an increasing problem. Patients are initially placed on antibiotics to treat some forms of bacterial infection. However, long-term or improper use of these drugs can cause microorganisms to change genetically to a form that is able to resist the antibiotic drugs. This genetically acquired resistance is passed down through generations of bacteria. Each successive generation becomes resistant to a new drug; thus creating a type of "super bug" that resists destruction by all available medications. Infections involving these resistant microorganisms may not be controllable and present a serious life-threat to infected persons.

The cliché "strength in numbers" applies to the infectious process. A small dose of an infectious agent is far less likely to cause a serious infection than a large dose. Depending on the type of organism, a small dose can often be controlled by the body's defense mechanisms; but a large dose may overwhelm the defenses and cause infection. Referring to our patient with appendicitis, if the appendectomy is performed before the appendix ruptures; a small number of *enteric bacteria* may escape into the abdomen during the procedure. The body has a far greater chance of defending against this small number than it does of defending against the massive dose of gross contamination resulting from a ruptured appendix.

Physical condition of the patient

There are many specific factors relating to a susceptible host's physical condition that influence the development and spread of an infection.

Age

As a rule, the older an individual is, the more susceptible he or she is to infections. Natural aging processes take their toll on once healthy body tissues and natural defense mechanisms. Frequently, elderly people are already debilitated with a variety of physical problems that weaken their bodies; making it easier for pathogens to get a foothold and spread rapidly.

Infants and young children are also more susceptible to disease and infection because their immune systems are not yet fully developed. We try to immunize young people against some of the most common viral diseases, but we cannot do this for all diseases. Many children, especially in underdeveloped areas, never receive the benefit of these vaccines. Most of a child's natural immunity comes from contracting a disease and allowing the body to form antibodies against the causative organism. Until children have been exposed to several diseases or have been vaccinated against them, they are subject to frequent infection.

Malnutrition

Obviously, if the body is not given the proper foods to form new cells and tissues to maintain existing structures, it becomes weak. Even a fully developed immune system will fail if there is no "fuel" to run it. Malnutrition affects infection like running out of diesel fuel affects an armored division during the middle of a tank battle. The enemy tanks overwhelm the tanks out of gas as easily as invading pathogens destroy tissues that are malnourished.

Obesity

Obese people are much more susceptible to infection for three main reasons. First, because their bodies have to work harder to supply the excess fat tissue with nutrients, there is less energy available to fight off infections. Second, fat tissue is an excellent breeding ground for microorganisms; especially for those that like warm, moist areas rich in organic carbon. Many of the most virulent bacteria fit into this category. Once they start to multiply in fat tissue, the infection spreads rapidly and is very hard to control. The third reason is similar to the second; the bacteria that like warm, moist areas thrive in the creases and folds of the obese person's skin, making the normal flora more abundant and more available to migrate to other areas.

Chronic disease

Individuals who suffer from long-term diseases, such as cancer, diabetes mellitus, and alcoholism, are more susceptible to infection. Chronic diseases weaken the body and tend to disrupt normal defense mechanisms, making the body less able to combat invading microorganisms. Some chronic diseases can cause skin ulcerations or other complications that break down natural barriers to infection. In the case of immuno-suppressive diseases, such as AIDS, the entire immune system is weakened, opening the body to numerous other diseases.

Remote infections

Like chronic diseases, individuals whose bodies are engaged in a battle with an infection in one area are much more likely to be infected with other pathogenic microorganisms in another location. For example, while our ruptured appendix patient is recovering from peritonitis, he or she is more susceptible to pneumonia, either from bacterial sources or viral sources, because to the immune system's resources are reduced.

Impaired defense mechanisms

A person with a condition that adversely affects the body's ability to produce antibodies is definitely put in grave danger of contracting numerous diseases. Such is the case with AIDS. Drug therapy involving steroids, therapy with drugs designed to prevent tissue rejection following organ transplants, and chemo-/radiation therapy also impair the body's immune system.

Type and techniques of surgery

The more involved the surgery, the longer it usually takes. The longer an operation takes, the greater the risk there is of contaminating the open wound. This can occur by airborne transmission of infectious agents (dust settling in the wound), indirect contamination caused by aseptic breaks, or droplet contamination from saturated surgical masks. Also, longer procedures generally produce more tissue trauma and insult to the body. The patient is weakened by blood loss, lack of nutrition, and the

side effects of anesthesia. All these factors combine to make major surgery patients highly susceptible to pathogenic microorganisms.

The surgical technique employed by a surgeon during an operative procedure can affect the rate of infection in two ways. First, surgery results in the intentional or unintentional placement of foreign materials in the patient's body. Sutures, staples, drains, catheters, and various implants are all materials surgeons intentionally place in body tissues. These foreign objects are necessary to treat the patient's diagnosed problem but can trigger an inflammation or infection if the patient's body rejects the foreign object. Unintentional foreign bodies can also find their way into the wound resulting in a foreign body inflammatory response. Common examples of unintentional foreign bodies include hair from surgical team members, glove powder, and lint from surgical sponges or drapes. Second, all surgery produces a certain degree of tissue trauma, but well-trained surgeons take every precaution to avoid rough handling of tissues. Such actions as rough sponging or rough manipulation and retraction of tissue can cause severe tissue inflammation and subsequent wound infection. Poor approximation of surgical wound edges can also contribute to a postoperative infection.

You can see there are many variables that are part of the infectious process. The key to stopping this process is to break any one link in this chain. In surgery, our best weapon to break the chain is aseptic technique, but, despite our best intentions and efforts, a patient may still be exposed to pathogens. Fortunately, most surgical patients have natural defense mechanisms to respond and defend against these pathogens.

204. The body's defenses and response to infections

In the previous lessons, we referred to the body's natural defenses against infection and the inflammatory response following introduction of infectious agents. We now elaborate on these subjects so you have a better understanding of the total infectious process. We start by discussing the body's natural defenses against infection.

Body defense mechanisms

There are five major defensive systems that the body uses to prevent entry of infectious microorganisms and the spread of infection—the skin, mucous membranes, tears, lymphatic system, and antibody formation.

The skin

Skin is the body's protective armor and its best natural barrier to infection. As long as this barrier remains intact and unbroken, it repels invasion of pathogens. If the skin is penetrated or removed in any way, then microorganisms have free access to the deep tissues that provide an ideal breeding ground for infectious agents. This is important for you to remember because it not only applies to surgical patients whose skin is incised, but also applies to you as a surgical team member. We have stressed the importance of handling sharp surgical instruments, needles, and blades with great care. This is not only to prevent being severely cut or stabbed, but also to prevent accidental infection by highly virulent microorganisms. A needle used on a patient with type B hepatitis or HIV is a potentially deadly item!

In surgery, we help enhance the protective nature of the patient's skin by performing preoperative skin preparation with antibacterial agents that leave a germ-killing residue. We also exercise great care in doing preoperative shave preps (when necessary) to avoid nicking or cutting the skin. Before injections or introduction of intravenous catheters, the patient's skin is antiseptically cleaned to avoid introducing infectious agents into deep tissues or the vascular system.

To protect *your* skin, always wear protective gloves when handling any contaminated or soiled items. If at all possible, avoid "scrubbing" if you have cuts or other breaks in the skin on your hands or arms. If harsh germicidal chemicals and soaps are drying and cracking the skin on your hands, use a

skin moisturizer (after duty) to keep the skin supple and moist. Remember, healthy skin is the best defense you and your patients have against infection.

Mucous membranes

Any tract or orifice of the body that communicates with the external environment is a potential entry point for infectious microorganisms. That's why nature provided us with moist, highly vascular mucous membranes to line most of these entry points. The nose, throat, respiratory and genitourinary tracts are all lined with protective mucous membranes that trap microorganisms. Since the membranes are well supplied with blood, any invading pathogen can be quickly destroyed by a massive influx of white blood cells that engulf and digest microscopic invaders. Some mucous membranes, such as those in the nose, have hairs projecting out of them that help filter and trap foreign matter. Other mucous membranes, like those lining the trachea, have tiny hair-like projections called *cilia* that also filter and trap foreign bodies, keeping them away from more susceptible inner body tissues. Last, mucous membranes can harbor certain microorganisms (*normal flora*) that aid in defending against infection by other microorganisms. One example of this is a type of bacteria normally found in the vagina that help keep the vaginal mucosa acidic. This acidic environment helps prevent the growth of harmful microorganisms and yeasts.

Tears

Tears are the eyes' protective fluid bath. They wash away dirt, debris, and microorganisms that could potentially cause inflammation or infection.

Lymphatic system

The lymphatic system is closely associated with the circulatory system. It consists of a system of vein-like, one-way vessels that return excess tissue fluid to the blood stream. The lymphatic system also contains specialized glands and nodes that play a key role in fighting infection by producing some types of large *leukocytes* (white blood cells) that are called *lymphocytes.* Lymph nodes in this system also act as mechanical filters that trap invading organisms and prevent them from entering the blood stream. During an infection, *lymphocytes* and *leukocytes* attack, engulf, and digest the pathogenic microorganisms in the tissues. The lymphatic vessels also transport pathogens to regional lymph nodes and glands where they are trapped and destroyed by *lymphocytes* contained in the lymphatic tissue before they can enter the bloodstream.

The tonsils, adenoids, spleen, and thymus gland are parts of the lymphatic system. When your tonsils (if you still have them), or the glands in your jaw swell and are inflamed, it is a sign these glands are waging war against invading pathogens. The battle is concentrated at those sites. One of the reasons ear, nose, and throat (ENT) surgeons do not routinely remove the tonsils and adenoids of young children anymore (it was once a routine practice), is because these glands play a key role in protecting the body against disease.

In addition to the *lymphocytes* produced in the lymphatic system and transported to infection sites by the circulatory system, the body contains other large pathogen-ingesting cells called *macrophages* or *histiocytes.* These cells are found in the walls of blood vessels and in loose connective tissue. Many of these *macrophages* remain fixed in the tissue and attack any invading foreign organism that comes near them. Some *macrophages* remain immobile until activated by an inflammation; then they begin to wander, destroying foreign organisms they encounter.

Antibody formation

A part of every normal person's defensive arsenal is the immune system that creates substances called *antibodies.* These antibodies are substances created in the body to attack specific foreign substances generally classified as *antigens. Antigens* stimulate the manufacture of antibodies and can include such harmful agents as bacteria, foreign tissue cells, toxins, or foreign proteins. Immunity provided by antibody production can be naturally acquired by contracting a certain disease, or it can be artificially induced by inoculating a person with a vaccine or toxoid (antigen) related to the disease.

Body responses to infection

Now that you know more about the body's natural defense mechanisms, it is time to find out what actually happens when an infection starts and begins to spread.

When pathogenic microorganisms enter deep body tissues, the body responds with a defensive reaction commonly known as an *inflammatory response* or *inflammation.* This reaction can also be triggered when any foreign, physical, chemical, or biological agent enters the body.

The first reaction that occurs after microorganisms invade the injured tissues is an increase in the flow of blood to the area. The increased blood flow dilates the blood vessels in the area and carries large numbers of *leukocytes* to the damaged tissues. As a result, the tissues near the injury turn red and feel warm. The *leukocytes* carried by the blood engulf and digest invading pathogens.

After this initial attack, the blood flow to the area slows and swelling (*edema*) occurs due to the buildup of fluid in the injured tissues. The swelling causes pressure on the surrounding nerves and creates the sensation of pain. As more *leukocytes* are brought to the injured area, pus begins to form. Pus is actually an accumulation of live and dead microorganisms, dead leukocytes, and tissue fluid that combine to form a thick, white-colored substance. As you may recall, the process of pus formation is called *suppuration* and pus-forming infections are referred to as being *suppurative.*

Up to this point, the infection is *localized* near the injury or pathogen entry site. If it remains localized, it may form a boil or abscess. If the infection is too great to be controlled at the entry site, then the lymphatic system transports the infectious agents to regional lymph nodes where the battle intensifies. Infections that spread to the lymph nodes are called *regional infections* and are characterized by painful, swollen glands.

Sometimes, the infection wins the battle in the lymph nodes and spreads to the circulatory system. Once in the blood stream, the pathogens rapidly spread throughout the body tissues resulting in what is known as a *systemic infection.* If this systemic infection persists, the resulting condition is called *septicemia.*

You should now have a general understanding of the infectious process, including the elements in the chain of infection and how the body defends against it. It is important to remember that all it takes is breaking one link in the chain to stop the infection from occurring. Before we move on to the methods we use to "break the chain," answer the following questions to make sure you know what we are trying to break.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

203. The infection chain

1. List the "links" in the infection chain.

2. Define the term *normal flora.*

3. List five possible sources of contamination.

4. List the four major delivery methods of disease transmission.

5. The *contact route of transmission* includes what three specific modes?

6. What route of disease transmission is commonly used by bacteria that cause food poisoning?

7. What is a vector?

8. List some common entry points for pathogenic microorganisms.

9. Briefly describe how the number of invading microorganisms applies to infection.

10. What three age groups are more susceptible to infection and disease?

11. Why are obese people more likely to become infected?

12. Name three things that could impair the body's normal immune system?

13. What is the relationship between the length of surgical procedures and infection rates?

14. How can surgical technique influence infection rates?

204. The body's defenses and response to infections

1. What is the body's best natural barrier to infection?

2. How do mucous membranes defend against infection?

3. How do tears defend against infection?

4. What role does the lymphatic system play in the body's disease defense system?

5. What are antibodies?

6. What is a regional infection?

Answers to Self-Test Questions

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1. Parasites rely on living hosts to sustain their existence; saprophytes live off dead or decaying organic matter.
2. Pathogenic.
3. The microorganism can become pathogenic and cause an infection.
4. Any microorganism that normally lives in the deep cracks and folds of the skin or commonly resides in body orifices.
5. A microorganism that has a very short life span and resides on the external surfaces of an object or live organism.
6. Bacteria and viruses.
7. Cocci–round; bacilli–rod-shaped; and spirilla–spiral-shaped.
8. Between 68° and 104° F (20° and 40° C).
9. Moist.
10. Strict (obligate) aerobes; strict (obligate) anaerobes; and facultative anaerobes.
11. A neutral or slightly alkaline environment; pH 7.0 or slightly above.
12. Spores are inactive, round, dry, thick-walled bodies found within bacterial cells. The spore may form in the center, off-center, or at the end of the rod-shaped cell. When a bacterial cell forms a spore and becomes inactive, it is referred to as a *dormant* cell. The spore contains enough genetic material to make it capable of developing into a living, vegetative bacterial cell when favorable growing conditions return.
13. Viruses are much smaller than bacteria. They are so small that they pass through bacterial filters and can only be seen with an electron microscope.

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1. Bacteria that cause wound infections.
2. Staphylococci.
3. Septic sore throat (“strep” throat), scarlet fever, impetigo, bacterial endocarditis, rheumatic fever, neonatal meningitis, and pulmonary infections such as lobar pneumonia.
4. Gonorrhea, conjunctivitis, septicemia.
5. Through droplet inhalation or from direct contact with the source.
6. Escherichia coli.
7. Spore-forming bacteria.
8. *Clostridium perfringens* (*welchii*)–”gas gangrene” (clostridial myonecrosis); *Clostridium tetani*–”lockjaw” (tetanus).
9. A wax-like protective coating surrounding the cell.
10. Rhinoviruses.
11. Tell your supervisor so you can go to sick call and be kept away from direct patient care. A simple cold or case of the flu that a healthy person would recover from in a few days can do serious harm to, and potentially kill, a surgical patient.
12. Hepatitis virus types A and E–infectious hepatitis; Hepatitis virus types B, C, and D–serum hepatitis.

13. Hepatitis virus types B, C, and D.
14. Herpes virus hominis.
15. HIV.
16. The AIDS virus (HIV) is spread via contact with infected blood, blood components, or other body fluids. When the HIV virus develops into AIDS, it virtually destroys the body's immune system.

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1. (1) An infectious agent (pathologic microorganism).
   (2) Reservoir, or place the infectious agent can multiply or grow.
   (3) Portal of exit from the reservoir.
   (4) Mode of infectious agent transmission.
   (5) Portal of entry into the body.
   (6) Host or person susceptible to the pathogenic organism.
2. Refers to microorganisms that normally reside on or in a certain body area.
3. Skin, hair, body orifices, infected substances from other people, and fomites (inanimate contaminated objects).
4. Contact, vehicle, airborne, and vector.
5. Direct contact, indirect contact, and droplet contact.
6. Vehicle or common source route.
7. Any live carrier, especially a rodent or insect, which transfers an infectious agent from one host to another.
8. The mouth and nose (most common), eyes, genital openings, anus, and breaks in the skin from incisions or other invasive procedures.
9. A small dose of an infectious agent is far less likely to cause a serious infection than a large dose. Depending on the type of organism, a small dose can often be controlled by the body's defense mechanisms; but a large dose may overwhelm the defenses and cause infection.
10. Elderly people, infants, and young children.
11. Because their bodies have to work harder to supply the excess fat tissue with nutrients, there is less energy available to fight off infections, and fat tissue is also an excellent breeding ground for microorganisms.
12. Diseases (such as AIDS), drug therapy, chemotherapy, radiation therapy.
13. Generally, the longer the procedure, the greater the chance of wound contamination and infection.
14. Surgery can result in intentional or unintentional introduction of foreign materials into the body, which can lead to inflammation and infection. Also, poor wound approximation and rough handling of tissue can lead to severe tissue inflammation and subsequent infection.

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1. The unbroken skin.
2. The moist surfaces of the membranes trap microorganisms. This is enhanced in some areas by cilia or hairs growing out of the membranes. Also, the mucous membranes are highly vascular enabling white blood cells to be rapidly supplied to the area of pathogen invasion. They may also harbor normal flora that combat pathogens.
3. They wash away dirt, debris, and microorganisms that could cause infection.
4. The lymphatic system contains special nodes and glands which produce large leukocytes, called lymphocytes, which engulf and destroy invading pathogens. Also, the lymphatic system transports pathogens to regional lymph nodes where they are trapped and destroyed, before they can enter the bloodstream.
5. Substances created in the body to attack specific foreign substances called antigens.
6. An infection that has spread to the lymph nodes.

Do the Unit Review Exercises (URE) before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to Field Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

1. (201) What are saprophytes?
   a. Microorganisms that rely on a living host to sustain their existence.
   b. Viruses with a short life span that commonly reside in body orifices.
   c. Microorganisms that live and grow off dead or decaying organic matter.
   d. Fungi that require high humidity and high temperatures for optimum growth.

2. (201) Microorganisms that normally live in the deep folds and cracks of the skin or in body orifices are called
   a. resident.
   b. transient.
   c. pathogenic.
   d. non-pathogenic.

3. (201) What is the shape of bacteria that are classified as cocci?
   a. Rod.
   b. Spiral.
   c. Round.
   d. Hexagonal.

4. (201) Bacterial cells that are rod-shaped are classified as
   a. cocci.
   b. bacilli.
   c. spirilla.
   d. flagella.

5. (201) What type of microorganism *only* multiplies within living cells and requires the use of an electron microscope to be seen?
   a. Spores.
   b. Protists.
   c. Viruses.
   d. Spirochetes.

6. (202) Bacteria that cause wound infections are called
   a. hosts.
   b. pyogens.
   c. pyrogens.
   d. normal flora.

7. (202) What group of bacteria causes the *most* common type of postoperative wound infections?
   a. Spirochetes.
   b. Streptococci.
   c. Enteric bacilli.
   d. Staphylococci.

8. (202) Which of the following bacteria is a spore-former that causes gas gangrene?
   a. Clostridium tetani.
   b. Treponema pallidum.
   c. Clostridium perfringens.
   d. Mycobacterium tuberculosis.

9. (202) Which type of bacteria has a wax-like coating around the cells that makes it difficult to destroy?
   a. Escherichia coli.
   b. Proteus mirabilis.
   c. Pseudomonas aeruginosa.
   d. Mycobacterium tuberculosis.

10. (202) The disease we call the “common cold” is caused by
    a. a herpes virus.
    b. enteric bacilli.
    c. tubercle bacilli.
    d. numerous rhinoviruses.

11. (202) Which virus causes infectious hepatitis?
    a. Herpes virus hominis.
    b. Hepatitis virus type A.
    c. Hepatitis virus type B.
    d. Human immunodeficiency virus.

12. (203) What term is used to describe any inanimate object capable of harboring and transmitting a disease?
    a. Carrier.
    b. Fomite.
    c. Vector.
    d. Reservoir.

13. (203) What mode of disease transmission can occur if you handled a bloody sponge with your bare hands and then fail to wash your hands before touching a new patient?
    a. Vector route.
    b. Vehicle route.
    c. Direct contact.
    d. Indirect contact.

14. (203) A live carrier, such as a rodent or insect, that transfers an infectious agent from one host to another is called a
    a. vector.
    b. vehicle.
    c. parasite.
    d. saphrocyte.

15. (203) Which physical condition does *not* generally influence the development and spread of infection?
    a. Age.
    b. Sex.
    c. Obesity.
    d. Malnutrition.

16. (204) What is the body's *best* natural defense against infection?
    a. Cilia.
    b. Skin.
    c. Tears.
    d. Mucous membranes.

17. (204) What are leukocytes?
    a. Plasma.
    b. Platelets.
    c. Red blood cells.
    d. White blood cells.

18. (204) What is the term for any foreign substance that stimulates the production of antibodies?
    a. Fomite.
    b. Antigen.
    c. Mesosome.
    d. Immunoglobulin.

19. (204) Infections that have spread to the lymph nodes are called
    a. localized.
    b. regional.
    c. systemic.
    d. septic.

Please read the unit menu for unit 2 and continue ➔

Student Notes

Unit 2. Infection Control Programs

AS YOU SHOULD RECALL, infectious agents come from several sources and are transmitted in many ways. To prevent surgical wound infections and reduce the spread of potentially pathogenic microorganisms, we employ several infection control measures.

We begin this unit covering the basic structure and organization of the hospital infection control program. Understanding the basic, overlying policies and programs that comprise the infection control system will provide a vivid framework which makes the operational steps (which follow) both purposeful and absolutely essential.

Infection control measures taken before, during, and after surgery are generally referred to as *surgical asepsis*. Surgical asepsis may be simply described as the methods or treatments used in surgery to prevent the introduction of pathogenic microorganisms to the patients and staff. The goal of most aseptic measures is to either reduce the numbers of, or to totally eliminate, microorganisms from the environment. Surgical asepsis begins with the practice of basic techniques such as personal hygiene, special attire, and sanitation.

2–1. The Infection Control Function

The Joint Commission (TJC) requires every hospital to have an active, effective, hospital-wide infection control program to receive accreditation. Not only is infection control important for accreditation, it is absolutely necessary to ensure that the risk of infection—for both patients and staff members—is minimized. We now look at some of the infection control measures and programs found in Air Force medical facilities, particularly those related to surgery.

Infection control encompasses a variety of activities inside and outside the surgical suite. This subject is so broad that a complete, detailed discussion is impractical for this text. So, we limit our discussion of infection control the major topics of concern to surgical personnel.

205. The infection control structure and organization

The goal of the infection control function is to identify and reduce the risks of *acquiring* and *transmitting* nosocomial infections among patients, employees, physicians and other independent licensed practitioners, contract service workers, volunteers, students, and visitors. *Nosocomial* infections are those identified as hospital associated or hospital acquired. In other words, they are infections the patient developed as a result of entering the hospital.

As a surgical technician, you play a key role in preventing infections not only in your patients, but also in reducing risk of exposure to yourself and many others as well. As you'll recall from previous lessons, a surgery technician can be exposed to many types of really nasty microorganisms.

General standards

The Centers for Disease Control and Prevention (CDC) is a US Public Health Service agency that provides valuable information to hospitals outlining how infection control programs should be developed and operated. The CDC also assists hospital infection control personnel in solving infection problems, analyzing infection survey data, and investigating the outbreak of serious

infections or disease. One of the CDC's most important functions is conducting research and publishing guidelines on a variety of infection control topics. We use many of these published guidelines for developing infection control programs, policies, and procedures.

In addition to the CDC, numerous other government agencies and private organizations provide information, guidance, and consultation services to hospital infection control personnel. These agencies include local, state, and federal public health services, the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), the Accreditation Association for Ambulatory Health Care (AAAHC), and the JC. Information regarding surgery-specific infection control practices is also found in publications provided by the Association of Surgical Technologists (AST), American College of Surgeons, the Association for the Advancement of Medical Instrumentation (AAMI), and the Association of periOperative Registered Nurses (AORN). The JC establishes the criteria by which hospitals are evaluated and accredited, Processing Departments are governed by AAMI and accredited, and the AAAHC establishes the criteria by which ambulatory organizations are evaluated and accredited. Infection control programs are a major area of consideration. To attain certification, the JC requires that each facility have a coordinated process to reduce the risks of nosocomial infections in patients and healthcare workers, and this process must be managed by one or more qualified individuals. In most facilities, the infection control process is managed by an infection control committee.

The Infection Control Committee

The Infection Control Committee (ICC) is governed by AFI 44-108, *Infection Prevention and Control Program* and is a multidisciplinary committee charged with managing the infection control program (ICP). The executive committee of the medical staff oversees the ICC, and only they can override the recommendations or actions of the ICC (a very rare occurrence). The ICC members are responsible for informing personnel of the committee's decisions and actions as well as their own individual responsibilities. Each ICC member must also promote awareness of and compliance with existing infection control directives.

Functions of the ICC

Air Force medical facility ICCs implement the most current standards of JC or AAAHC inspection standards appropriate for the facility type (i.e., hospital, ambulatory or home health environment). The committee must clearly define nosocomial infections and establish a system of reporting and investigating infections among patients, personnel, and visitors. They also keep records of infections and their recommendations for remedial measures. The committee distinguishes, to the best of its ability, between nosocomial infections and other types of infections. The ICC interacts with other committees as needed.

Infection preventionist

An infection preventionist (IP) will be appointed in writing by the unit commander. This individual must be an officer or civilian equivalent with a minimum of three years clinical experience in their field (i.e., nursing, dental, lab, public health, and medical).

Departments, patient care units, and support areas

Each department, patient care area, and support facility develops and maintains written area-specific operating instructions (OI) explaining policies and procedures for infection control. Each area is responsible for reviewing the documents annually and revising as necessary. The ICC reviews and approves these OIs *at least* every two years. Two exceptions to this rule are the bloodborne pathogen exposure control plan (required by OSHA) and patient isolation plans which are reviewed annually.

206. Components of infection control programs

While the infection control process is complex, it is generally divided into two major functions: surveillance and prevention/control of infections (some texts consider prevention and control

separately). These components are not independent; they are related to and dependent upon each other, forming a continuous loop of infection control activities.

Surveillance

Surveillance includes data collection, analysis, and reporting; we gather as much information as possible about our infection "enemy" to help us defeat it. We collect detailed information on all patient infections encountered in our hospitals. This information is reported by the individual units to the infection control committee. This information establishes the *rate* of infection—defined as the percentage of patients who acquire infections per patient day. We monitor the infection rates of different services, individual units, and other specific areas to determine problem areas. We also look at whether the problem is isolated or whether we have an outbreak of infection.

Surveillance data is also analyzed to track *trends* of infection; we look at infection rates and each infection for common links or events that tend to cause infection in our patients. One of the tools we use in surveillance of surgical wound infections is a classification system.

Surgical wound classification

Surgical patients run a greater risk of developing a nosocomial infection than any other group of patients. In fact, studies done by the CDC indicate that approximately 70 percent of all hospital-acquired infections occur in patients who undergo surgery. Most of these infections are not related to the wound, but to instrumentation of the urinary and respiratory tracts.

The CDC cites surgical wound infections as being the second most frequent source of nosocomial infections, next to urinary tract infections, and considers them to be a major cause of increased hospital costs, disease, and death. Because surgical wound infections are such a major problem in all hospitals, you need to become familiar with how they are classified and what basic steps can be taken to prevent them.

Any post-operative wound that emits *purulent* (pus-containing) drainage is defined as a surgical wound infection. A surgical wound is also considered infected if the surgeon diagnoses it as such.

Wounds are classified by the degree of probable microbial wound contamination during surgery. Because the classification depends on the conditions encountered during surgery, a CDC surgical wound classification should be assigned to each case *at the end of the procedure*. The CDC outlines four classifications for surgical wounds—Class I–clean wounds; Class II–clean-contaminated wounds; Class III–contaminated wounds; Class IV–dirty wounds.

CDC Classification for Surgical Wounds	
Class/Name	**Description**
I. Clean Wounds	Clean wounds are uninfected wounds in which: • No inflammation is found. • No breaks in surgical technique are made. • The respiratory, digestive, or genitourinary tracts are not entered. The probability of a clean wound becoming infected is between 1 and 5 percent. Examples of this type of surgical wound include those created during breast biopsies, thyroidectomies, and hernia repairs.
II. Clean Contaminated Wounds	This category of surgical wounds includes any procedure where the respiratory, digestive, or genitourinary tracts are entered under controlled conditions without unusual contamination. Examples of operations that normally fall under this category include cholecystectomies and vaginal hysterectomies. This category also includes cases where only a minor break in surgical technique occurs. This type of wound has an 8 to 11 percent chance of becoming infected.

CDC Classification for Surgical Wounds	
Class/Name	**Description**
III. Contaminated Wounds	Wounds in this category include: • Any open, traumatic wounds. • Operations with major breaks in surgical aseptic technique or gross spillage from the intestinal tract. It also includes cases where severe non-purulent inflammation is encountered. Removal of an inflamed, but unruptured, appendix is an example of an operation that normally falls under this category. Contaminated wounds have a 15 to 20 percent risk of infection.
IV. Dirty Wounds	This category includes old traumatic wounds with: • Areas of dead tissue. • Evidence of gross spillage of intestinal contents. • Acute infection. This category includes cases where microorganisms are present at the surgical site before the procedure, or if the patient has an infection or bacterial inflammation. An operation to incise and drain a pus-filled abscess is an example of a “dirty” case. Dirty wounds have a risk of infection of over 27 percent.

Surgical wound infection classification serves several purposes in the infection control program. First, it helps infection control personnel predict the relative probability that a certain type of wound will become infected. Second, surgeons use it to evaluate their own infection rates and compare their surgical techniques to those of other surgeons. Third, the classification system alerts surgical personnel to wounds that run a high risk of infection; thereby enabling them to take appropriate prevention and control measures.

Prevention and control

Prevention of infection refers to the measures we take to keep patients and personnel from acquiring infections. Control refers to the measures we take to keep infections from spreading. Because the measures we take to prevent or control infections are often the same, we generally consider prevention and control as a single function.

Each area of the hospital has specific practices and measures to prevent and control infections. A detailed discussion of all hospital-wide measures is impractical for this text; you should learn and follow the local policies and guidelines that apply to your medical treatment facility. Some specific measures for prevention and control of infection have been developed that apply to all facilities and all personnel; the two categories of these measures are standard precautions and transmission-based precautions.

Standard precautions

The CDC has issued *Standard Precautions* that apply to

- Blood.
- All body fluids, including secretions and excretions.
- Non-intact skin.
- Mucous membranes.

As you can see, this means standard precautions must be used for all surgical procedures, and for most patient contact. You must use standard precautions daily, so you should ensure you fully understand what they are and where they apply. Standard precautions are discussed in the following table.

Standard Precautions	
Application	**Description**
Hand washing	• Wash your hands after touching blood, body fluids, secretions, excretions, and contaminated items, *even if you were wearing gloves*. • Wash your hands after removing gloves, between all patient contacts, and whenever you may potentially transfer microbes to other patients or areas. • Use an ordinary cleansing agent (soap) to wash your hands unless specific circumstances require you to use an antiseptic. Local infection control policy determines the agent you use.
Gloves	• Wear clean, non-sterile gloves when touching blood, body fluids, secretions, excretions, and contaminated items. • Put on fresh gloves *before* touching mucous membranes or non-intact skin. • Remove gloves *immediately after use* and *before touching non-contaminated items or surfaces*. Also put on fresh gloves before going to another patient. • Remember to wash your hands when changing the gloves. **NOTE:** Wear of sterile gloves is discussed when we look at aseptic technique later in this volume.
Mask, eye protection, face shield	Wear a mask and eye protection or a face shield to protect mucous membranes of the eyes, nose, and mouth during patient care activities that are likely to generate splashes or sprays of blood, body fluids, secretions, and excretions.
Gown	• Wear a gown (a clean, nonsterile gown is adequate for non-invasive procedures) to protect skin and prevent soiling of clothing during activities that are likely to generate sprays or splashes of blood, body fluids, secretions, or excretions, or likely to cause soiling of clothing. • Select a gown that is appropriate for the activity and amount of fluid likely to be encountered. • Remove a soiled gown as promptly as possible and wash hands to avoid transfer of microorganisms.
Patient care equipment	• Handle used patient care equipment contaminated with blood, body fluids, secretions, or excretions in a manner that prevents exposure or contamination of clothing, patients, and other environments. • Ensure reusable equipment is not used to care for another patient until it has been cleaned, decontaminated, and reprocessed. • Ensure that single-use items are properly discarded.
Linen	Handle, transport, and process used linen soiled with blood, body fluids, secretions, or excretions in a manner that prevents exposure or contamination of clothing, patients, and other environments.
Bloodborne pathogens	1. Use mouthpieces, resuscitation bags, or other ventilation device as an alternative to mouth-to-mouth resuscitation in areas where the need for resuscitation is predictable. 2. Take care to prevent injuries when using needles, scalpels, and other sharp instruments or devices; when handling sharp instruments after procedures; when cleaning used instruments; and when disposing of needles. • Never recap used needles or otherwise manipulate them using both hands; or any other technique that involves directing the point of a needle toward any part of the body. Use either a one hand “scoop” technique or a mechanical device designed for holding the needle sheath. • Do not remove needles from disposable syringes by hand, and do not bend, break, or otherwise manipulate used needles by hand. • Place used disposable syringes and needles, scalpel blades, and other sharp items in appropriate puncture resistant containers located as close as practical to the area in which the items were used. • Place reusable syringes, needles, and other sharp items in a puncture resistant container for transport to the reprocessing area.

In addition to these standard precautions, additional precautions must be taken for some patients.

Transmission-based precautions

The CDC has also issued *transmission-based precautions* to be used on patients who are known or suspected to be infected by pathogens known to be transmitted by airborne, droplet, or contact routes (refer to lesson 202 if you forget what these methods are). These patients are generally kept isolated from other patients, and staff and visitors must take special precautions to prevent spreading of the illness. The disease or conditions necessitating these precautions usually prevent these patients from being candidates for elective surgery, but you may come across these conditions in emergency or critical surgery patients.

Airborne precautions

Airborne precautions apply to patients with illnesses, such as measles, chicken pox, and tuberculosis. The patients are usually kept in an isolation room with negative air pressure. Staff members who are susceptible to measles or chicken pox (have not been immunized) should avoid contact with patients with these illnesses. All staff members and visitors should wear surgical masks in the presence of tuberculosis patients. During transport, the patient should wear a surgical mask to reduce spreading the microbes.

If operative procedures must be performed on these patients, the doors must remain closed and traffic should be greatly restricted. Opening or closing the doors, and staff moving around the room, generate air currents and disperse the microbes. If possible, the procedure is performed when other patients are not in the surgical suite (such as at the end of the day). Anesthesia providers should take special precautions in selecting the equipment and ventilation method to reduce airborne microbes and equipment contamination.

Droplet precautions

Droplet precautions apply to patients with illnesses that can be transmitted through droplets generated by talking, coughing, sneezing, or otherwise. Illnesses in this category include meningitis, pneumonia, sepsis, and many others. All staff members and visitors should wear surgical masks when within three feet of the patient. During transport, the patient should also wear a surgical mask. In surgery, most of the precautions for airborne microbes are also applied for droplet precautions.

Contact precautions

Contact precautions apply to patients with illnesses that may be transmitted via direct or indirect contact. Fortunately, most of the conditions that fall into this category are rarely seen. However, these precautions should be used for patients with herpes virus and some antibiotic-resistant strains of infection. Generally, contact precautions are the same as standard precautions, except they *apply to all patient contact* rather than to only blood, body fluids, secretions, and excretions.

- Masks, gloves, and a gown should be worn by all in the presence of the patient.
- Hand washing is essential.
- All patient care equipment and supplies must be properly handled and decontaminated after use.
- When possible, disposable or patient-dedicated equipment should be used.
- Transport of the patient should be avoided, but if necessary, precautions must be taken to prevent contact with other staff, patients, or visitors.

These precautions are echoed in various areas throughout this volume, as well as in other areas of this course. The rest of this volume deals with infection prevention and control measures you, as a surgical technician, practice routinely. To ensure you have a solid foundation of infection control knowledge, answer the following questions, and review the answers you are not sure of.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

205. The infection control structure and organization

1. What is the goal of the infection control function?

2. What US Public Health Service agency provides valuable information and assistance to hospitals on infection control matters?

3. Name some other agencies or organizations, besides the CDC, that provide infection control guidance, information, and consultation services?

4. Who can override recommendations of the ICC?

5. Who is usually appointed to act as the hospital infection preventionist?

206. Components of infection control programs

1. What are the two major functions of the infection control process?

2. List some surveillance techniques.

3. What surgical wound is considered to be infected?

4. When should the surgical wound classification be assigned?

5. How do you classify a surgical wound that is uninfected, is not inflamed, and the respiratory, digestive, and genitourinary tracts have not been entered?

6. What characteristics distinguish dirty or infected wounds from other classifications of surgical wounds?

7. To what substances do the *Standard Precautions* (published by the CDC) apply?

8. When should you wash your hands?

9. When should you wear, and change, gloves?

10. What should you wear to protect mucous membranes of the eyes, nose, and mouth during patient care activities that are likely to generate splashes or sprays of blood, body fluids, secretions, and excretions?

11. List some of the guidelines for handling and disposing of contaminated sharps.

12. List the three categories of transmission-based precautions.

2–2. Basic Infection Control Measures

In surgery, infectious agents may come from environmental sources, but they are more commonly transmitted by direct contact of surgical personnel with the patient's wound. To reduce this method of transmittal, we start by maintaining excellent personal hygiene and developing good handwashing habits.

Before you can enter the "inner sanctum" of the surgery suite, you must change into appropriate surgical attire. The reason special clothing and other attire is worn in the OR (operating room) is to help protect patients and staff. Surgical attire helps to minimize the amount of bacteria carried into the operating room and contain the bacteria shedding from hair, skin, and body orifices. Some of the attire you wear is to protect the surgical environment and the patient, some you wear to protect yourself, and some you wear to do both. Recommendations for surgical attire are continuously updated, so follow the specific guidelines established in your facility; the guidelines discussed here are general in nature.

207. Personal hygiene and surgical attire

Infection control begins with you! Your personal hygiene habits and the practices you develop for personal cleanliness can greatly reduce the likelihood of you personally transmitting or acquiring an infection. You must practice impeccable personal hygiene, and must make proper handwashing a routine.

Personal hygiene

Personal hygiene starts at home. It begins the moment you wake up each morning. Just as surgical patients are required to take preoperative showers to reduce the level of transient and resident bacteria on their skin and hair, so must the surgical staff member. Hair shampooing is a must. Hair is an excellent bacterial breeding ground and needs to be kept very clean, dandruff-free, and styled in a fashion that ensures it is completely covered and contained by a surgical head cover (cap).

Nails should be relatively short; long nails can scratch your patients and puncture sterile gloves. They also collect dirt that is hard to remove. Nail polish should not be worn. Chipped nail polish can harbor microorganisms and also causes foreign body reactions if introduced into a wound. Artificial nails are forbidden! Fungal growth occurs if moisture gets trapped between the natural and artificial nail.

If you use cosmetics, use them sparingly. Excessive makeup harbors microorganisms and can easily shed. Makeup is *not* antiseptic; it only covers the bacteria on your skin, and sometimes provides a growing medium for them. If makeup sheds into a wound, the chemicals in it can cause a severe foreign body reaction and the bacteria it carries with it can cause a wound infection.

Non-hygienic personal habits such as scratching or rubbing various parts of your anatomy, picking your nose, or popping pimples, are not acceptable for surgical personnel. The absolute *strictest personal cleanliness is a must.*

Wearing of jewelry in the operating room is also not recommended. When jewelry is permitted by local policy, it must be contained inside (under) normal surgical attire. Circulating personnel may be allowed to wear a watch and a ring, but they must be removed for hand washing. Hand and wrist jewelry must also be removed anytime gloves are donned, whether performing sterile tasks such as patient preps, or nonsterile tasks such as removing bloody sponges from kickbuckets. Scrub personnel may not wear any jewelry on the hands and arms, this includes wedding rings. The bottom line: the less jewelry worn, the fewer places bacteria have to grow on your body, and the less chance of you passing an infectious agent on to your patients or co-workers.

One area of personal hygiene frequently overlooked is keeping healthy. This includes getting enough rest (after duty!). Assisting a surgeon with an operation requires your undivided attention and full concentration, neither of which you can give if you are tired or ill. If you feel ill, tell your supervisor. Sick people are not usually allowed to render patient care; the risk of them infecting patients or coworkers outweighs the benefits of keeping them on the job. Do not be a martyr! Tell your supervisor if you feel unwell, and go to sick call. Also tell your supervisor if you have any open wounds, rashes, boils, severe acne, or other skin ailment. For your patient's—and your own—protection, you do not want any open sores on your skin that may become infected or infect someone else.

Hand washing

Hand washing is considered one of the most important procedures health care personnel perform to control infections in hospitalized patients. Research shows hospital personnel are the mode of transmission for most preventable nosocomial infections. In many instances, the hands of personnel have been identified as the probable means of cross-infection, so it is extremely important that you learn proper hand-washing techniques and develop the habit of washing your hands frequently throughout the day. Frequent hand washing is one of the best methods of preventing cross-contamination.

- Wash your hands before starting duty, before and after meals (or breaks), after visits to the bathroom, before handling clean items, and before going home.
- Wash your hands after every contact with a patient or patient contact item.
- Wash your hands before and after contact with wounds, before and after contact with high-risk patients (newborn infants, infectious disease patients, etc.), before and after every invasive procedure, and after handling closed invasive systems, such as urinary drainage bags or wound drainage devices.
- Also wash your hands before donning and after removing gloves.

Before we discuss specific hand-washing techniques, you need to understand the purpose of hand washing. In simple terms, hand washing is done to remove the contaminants your hands pick up from various sources to keep them from contaminating the rest of your body or other things you touch. You can use a variety of hand-washing agents, from simple soaps to antiseptics, but plain soap is

recommended by the CDC for routine handwashing. Soap and detergents simply suspend microorganisms and soil, allowing them to be washed off the skin; they are usually gentle on the skin.

In contrast to hand washing, the surgical scrub is done to remove transient and resident bacteria from your hands and arms to minimize the chances that you will infect a patient with microorganisms from your skin. Antiseptics control and kill microorganisms on the skin and other superficial tissues, and are generally harsher than soaps. You learned about some antiseptics, such as those you use when performing a surgical hand and arm scrub, in technical school, and we discuss them more in detail later in this course.

Regardless of the agent you choose, the following techniques are recommended for hand washing.

Hand Washing Technique	
Step	**Discussion**
Remove jewelry	This includes all rings and watches.
Expose forearms	If you are wearing a long-sleeved garment, either remove it or roll up the sleeves.
Turn on and adjust the water	• Many hospital sinks have hands-free controls. • If you must use your hands to turn on or adjust the water, protect the controls by using a paper towel or similar barrier. This prevents you from contaminating the knobs before you begin your wash. • Adjust the water temperature (if possible) so it is comfortably warm and the flow is slow and steady. Warm water makes better lather and is less damaging to the skin than cold or hot water.
Develop lather	• Wet your hands thoroughly. • Then using the cleansing agent, lather them to just above the wrists. • (Higher up the arms if they are also contaminated; wash any areas you think may be contaminated.). • As opposed to the surgical scrub, keep your hands *lower* than your arms to prevent the contaminated soap and water from running up the cleaner areas of your arms.
Scrub hands	• Rub your hands together, using small circular motions. • Be sure to clean all areas of your hands, including the hard to reach areas between the fingers. • Re-lather hands as necessary to ensure you have plenty of suds. • If you are using bar soap, hold onto the soap throughout the entire hand wash process. If you set the soap down or drop it, re-wash. • Scrub the hands vigorously for at least 10 seconds; this mechanical scrubbing action does most of the work in removing gross soil and contaminants.
Clean nails	• If this is the first wash of the day, or if your hands are grossly soiled, clean your fingernails with a nail file or disposable nail cleaner. • Clean your nails using the same technique as for the surgical scrub. Clean them under running water to flush the contaminants down the drain.
Rinse	• Keep your hands below your elbows to allow the contaminated soap and water to run off your fingertips. • If you used bar soap, rinse off the bar and put it back in the soap dish just before rinsing your hands. • Avoid touching the soap dish and sink surfaces—they are probably more contaminated than your now clean hands.
Dry	• Dry your hands thoroughly, using either paper or single-use cloth towels. • Thorough drying reduces the likelihood of chapping or chafing.
Turn off water	If you must use your hands, protect them with a paper towel.

Hand Washing Technique	
Step	**Discussion**
Skin care	• If your hands are chapped or the skin is dry, use hand lotion to soften the skin and reduce the shedding of dead skin cells. • Keeping your skin healthy and clean reduces the level of microorganisms on it, and also keeps your most important protective barrier to infection (your skin) intact.

Now that you are clean and have washed your hands, let's look at how and why we dress the way we do in the surgical environment.

Surgical attire

When most people think of surgical attire, they think of the surgical "scrub" suit. While your scrubs are part of your surgical attire, there are numerous other components. Some of these components are worn whenever you are in the surgical suite (like the scrub suit); others are worn for specific purposes or for performing certain tasks (like the sterile gown when scrubbed-in). But generally speaking, the purpose of surgical attire is two-fold: to help protect the patient from infection, and to protect staff from contamination.

Surgical head cover

The first component of your surgical "armor" is a cap or hood; it should be donned *before* the scrub suit and other attire. As we mentioned before, hair holds and breeds bacteria. It also has a tendency to fall out. To protect the patient, we must minimize the shedding of hair and hair-borne bacteria. We do this by requiring surgical personnel to cover *all hair*—including facial, neckline, and hair on the head (a mustache is covered by a mask). There are many different types of surgical hair covers available; the two most common types are the generic bouffant style cap and hoods.

The bouffant style cap is very popular because it covers all the hair and the elastic conforms snugly to the sides of the head; there are no gaps for hair to escape. Many bouffant caps are made from a single layer of fairly porous material and should be worn only when fluid exposure is unlikely. Some bouffant caps are made from multi-layers or from less porous materials designed to withstand moderate exposure to fluids.

Hoods are preferred by some because they cover not only the hair on the top, back, and sides of the head, but also long sideburns and some facial hair. Hoods are commonly worn by orthopedic surgeons, especially when they are performing total joint replacement operations. Hoods generally offer better protection, but, like the bouffant caps, the level of protection depends on the materials used to make them.

The surgical head cover not only protects the patient from contamination by your hair, but also protects your hair from contamination by blood and body fluids. Select a hair cover according to the level of exposure anticipated. When deciding which cap is best for a particular situation, follow local policy and the manufacturer's recommendations.

"Scrub" suit

The body cover, or scrub suit, is the next part of your surgical attire. Your "scrubs" consist of a shirt and pants set and should fit fairly snugly to reduce the bellows effect of moving air. The shirt should always be tucked into the trousers at your waist. The ties on the pants should also be tucked in at the waist to prevent them from contaminating the sterile field when you are working in the OR. Change your scrubs daily; more often as conditions warrant (such as visible soilage).

Personal scrub attire is not allowed if it must be laundered at home; it may lead to the spread of microorganisms in the home, and its care cannot be adequately controlled to protect the surgical environment. Scrubs are worn to prevent bacteria and soil from your street clothes from

contaminating the surgical environment, and to prevent you from transporting pathogens and soil from surgery to outside environments.

Non-scrubbed personnel should routinely wear long-sleeved, elastic cuffed, jackets. Keep them snapped or buttoned during use. Long sleeves reduce microbial shedding from bare arms, and also meet requirements for personal protective equipment from light to moderate exposure to pathogen containing fluids.

Surgical scrubs are considered a utility uniform and will likely be your uniform of the day. Although the majority of your duties will be behind "the red line", you must continue to present a professional appearance and adhere to AFI 36-2903. For more specific guidance pertaining to your location, refer to local policies (i.e, OIs, or Medical Group Instructions (MDGI) for any additional requirements.

Footwear

Dedicated shoes (shoes used solely in the operating room) are recommended for use in surgery to reduce the amount of dirt, debris, and bacteria "tracked" in by street shoes. They are also recommended to reduce the likelihood of pathogens from the surgical suite being transported to other areas of the hospital. Shoes used in the operating room should be washable, comfortable, provide good support, and be protective. Sometimes you stand for long hours and when you do, you'll regret wearing a cheaply-made, non-supporting pair of shoes. Cloth shoes offer no barrier to blood-borne pathogens (strike-through). Open toes, open heel "clogs", and sandals do not protect from anything—they leave you particularly vulnerable to injuries from sharps and from falling instruments.

When dedicated shoes are not available, paper or plastic shoe covers are usually worn over street shoes to reduce tracking. Shoe covers are also recommended as a protective barrier when exposure to blood or body fluids may be expected, such as when scrubbed. Various types of shoe covers are available. Choose one that offers maximum protection from the type of exposure anticipated. The most common shoe cover covers only the shoe and is designed for areas with no or minimal likelihood of exposure. These are also used to cover your dedicated shoes when you leave the OR. Another type of shoe cover is the shoe and ankle cover which is designed for medium-risk exposure protection. The "boot" type shoe cover offers maximum protection; it is ideal for high-risk areas (such as the decontamination area when processing instruments). Change shoe covers as soon as possible if they become soiled, torn, wet, or otherwise compromised. To aid in housekeeping, and to reduce "tracking" of soil, remove shoe covers when soiled.

Surgical mask

A single surgical mask should be worn in restricted areas when open sterile supplies, sterile equipment, or other sterile fields are present. Many hospitals require you to wear a mask anytime you are in a restricted area. The mask should fit properly, covering the nose and mouth. It should be tied (secured) to prevent venting of non-filtered air. The air must pass through the mask filter, not out around your nose or chin. (This is why a double mask does not work; it acts as a barrier rather than a filter.)

Change your mask frequently because moisture reduces its filtration capability. As a minimum, change your mask between cases to reduce chances of cross-contamination. *Do not* wear it around the neck (or on top of your head). Also, do not shove it into a pocket and save for future use. To remove a mask, touch only the strings, not the pouch, and discard it immediately. You avoid touching the body of the mask because it contains the microbes filtered from the air you inhaled and exhaled. Always wash your hands immediately after mask removal and before donning a clean one.

Eyewear or face shields

According to the OSHA Bloodborne Pathogen Standard (and the CDC's standard precautions), protective eyewear or face shields must be worn when splash, spray, or other incident may result in personnel exposure. *This includes all surgical procedures.* Even minor invasive procedures require

the wear of protective eye wear to prevent contact with contaminated blood body fluids, secretions, or excretions.

There are numerous types and styles of protective eyewear and face shields available. Some eyewear is also special purpose, such as the colored lenses worn during laser surgery. Some eyewear and face shields are single-use, disposable; others are non-disposable. When non-disposable eyewear or shields are used, they must be decontaminated as soon as possible after exposure. Disposable items must be discarded.

Gowns

As you already know, a sterile gown permits you to enter and contact the sterile field. Some of the questions to consider when selecting the type of sterile gown to wear include:

Questions to Consider When Selecting Sterile Gown	
What is the risk of exposure to potential pathogens during the procedure?	Some procedures, such as myringotomy with insertion of drainage tubes, are low-risk. Other procedures, such as irrigation and debridement of an infected hip, are higher risk. You need a gown that offers maximum protection for high-risk procedures.
How effective a barrier is the gown?	Some gowns are fluid resistant; they offer adequate protection during low- to moderate-risk of exposure procedures. Other gowns are fluid-proof, offering maximum protection from strike-through for the patient and the staff member.
How tear or puncture resistant is the gown?	A lightweight paper gown may be adequate for a short, CDC class 1 procedure; a heavier, more resistant material offers better protection for longer procedures with a CDC class 3 or 4.
How much coverage does the gown provide?	Most gowns used in surgery are “wrap-around” and cover the front and back of the wearer. The length of sterile gowns varies; some stop above the knees of an average height person, others extend nearly to the floor. If the wearer is shorter or taller than average, you may have to select a different gown.
Is the gown relatively comfortable?	Some gowns are very stiff, making movement difficult or awkward. Some gowns do not breathe, they retain excessive heat. A gown that is too large or too small can also be uncomfortable.
Does local policy specify the specific type gown for the procedure?	If the surgeon’s preference card lists a specific gown, select that gown unless you specifically obtain permission to select another. Some facilities have determined specific personal protective attire (including the surgical gown) must be worn for specific procedures.

Some of your duties require you to wear an unsterile gown. An unsterile gown is worn primarily to protect you, not necessarily the patient, from pathogenic contaminants. The gown selected depends on the nature of the duty and the risk of exposure. For example, when you are decontaminating and cleaning instruments, you may wear a fully impervious gown; when transporting a patient from an isolation unit, you may simply wear a thin paper gown.

Aprons

Aprons are usually worn for specific purposes, and so are designed to meet the intended purpose. They are sometimes worn when decontaminating or cleaning items. They may also be worn under a sterile gown to form an additional barrier if heavy fluid exposure is anticipated. Lead aprons are worn to protect personnel from radiation exposure during procedures involving x-ray or fluoroscopy.

Coveralls

Like aprons, coveralls are also usually worn for a specific purpose, though some facilities use 1-piece coveralls as scrub suits. If local policy permits, coveralls may be worn by visitors to restricted and

semi-restricted areas. Specially designed, impervious or fluid-resistant coveralls may be worn in decontamination areas or when working with ethylene oxide sterilizers.

Gloves

Nonsterile latex (or latex-free), vinyl, rubber, and fabric gloves are worn to perform numerous duties. Single-use, disposable latex (or latex-free) gloves are worn when starting intravenous lines, when handling bloody sponges, for specimen preparation, and for numerous other procedures. Vinyl gloves may be worn for some of the same purposes. Rubber or rubber-like gloves may be worn for decontamination or for handling certain sterilants or other chemicals. Fabric gloves, usually terry-cloth, canvas, or leather, may be used to handle hot items such as when removing sterilizer carts from steam autoclaves. Lead gloves are available for certain radiology procedures.

Sterile gloves are worn for all invasive procedures. They complete the surgical attire for sterile team members. They may be made from substances such as latex, synthetic rubber, vinyl, or plastic, but must offer as much impermeability as possible.

Guidelines for special situations

Ideally, surgical attire is not worn outside the surgical suite. However, sometimes this is impractical due to the expense involved and because situations arise that require you to leave the department without taking time to change (i.e, a fire drill or emergency situation). If you must leave the surgical suite with your scrub clothes on, local policy dictates how you do so and what you must do upon return. You should always remove items considered as personal protective attire before leaving the department. This includes your mask and used shoe covers (exchange the shoe covers for new ones if you wear dedicated shoes). You must remove contaminated attire such as your gown and gloves before you leave the operating room. Some facilities require you to wear a “cover gown” or a lab coat over your surgical scrubs when leaving the surgical suite, others do not. Although acceptable in some medical facilities, the use of lab coats as cover garments is not generally recommended unless the lab coat is changed and laundered after each exit or entry. Ideally, surgical attire worn outside the department should be completely changed on return. Remember, you are not only concerned with carrying bacteria into the operating room, but you also may transport pathogenic infectious microorganisms out of the OR and into the patient care units and other hospital areas.

208. Sanitation and housekeeping

Cleaning and decontaminating the surgical suite are important elements of total surgical patient care. By creating and maintaining a biologically safe environment for patients and personnel, you not only contribute to effective infection control, but also to overall quality assurance. The primary purpose of all surgical sanitation activities is to reduce and control the possibility of cross-contamination between patients and surgical staff members by significantly reducing the number of microorganisms in the surgical environment.

Some operating rooms use 70 percent isopropyl alcohol for cleaning furniture because it evaporates quickly, minimizing the risk of accidental contamination of sterile supplies. However, alcohol is not a very effective germicide, so most policies require the use of tuberculocidal detergent-germicide solutions for all cleaning. Regardless of the solution you use, ensure all surfaces are dry before you place sterile supplies on them.

Surgical housekeeping activities are usually divided into categories or phases, each with its own unique cleaning and decontamination considerations. The phases of OR sanitation we discuss are start-of-day, during-case, after-case, between case, end-of-day, and periodic cleaning. The specific techniques and procedures used to clean the surgical suite are outlined in local policies as determined by the infection control committee. The procedures listed here are typical, but are *not mandatory* for all facilities.

Start-of-day cleaning

Although all operating rooms and adjacent areas in the surgical suite are thoroughly cleaned after each operative day, airborne microorganisms and particulate matter such as dust and lint settles on environmental surfaces overnight. To reduce these possible sources of wound contamination, certain housekeeping duties are performed before sterile surgical supplies are opened and the first patient of the day is brought into the operating room.

Each operating room is cleaned, usually by the scrub and circulator working as a team. The first step in start-of-day cleaning for each OR is to remove unnecessary furniture and equipment. Next, damp dust all horizontal surfaces in the operating room, starting with the highest, most sterile processing in the room, and working downward and outward in a spiral pattern. Usually, this means you start with the overhead surgical lights, move down to the OR bed, then progress outward. Be sure to dust the horizontal surfaces on all furniture and portable or wall-mounted equipment. Be careful not to drag your dusting cloth on the floor because this picks up contaminants that can be transferred to higher horizontal surfaces.

The aim of this cleaning is to remove the light coating of dust that settled since the room was last used; you should not have to scrub gross material from any surface (it was cleaned after the room was last used). You should be able to damp-dust fairly quickly, but take care not to miss any surfaces. Unless your local policies dictate otherwise, avoid touching the anesthesia machine; you may inadvertently damage or disturb the control mechanisms. In some operating rooms, only anesthesia personnel or other specially trained personnel are allowed to touch anesthesia machines and related equipment.

Once the OR is damp-dusted, move all mobile furniture to one side of the room. Apply detergent germicide solution to the bare floor, then roll all movable furniture onto the now wet floor and apply the solution to the other side. The device used to apply the solution varies, but it should apply the solution evenly. Rolling the furniture through the solution helps clean the wheels or casters. The final step in cleaning the operating room is to use a wet-vacuum to pick up the solution.

Clean the support areas outside the operating rooms (scrub rooms, sub-sterile rooms, etc.) the same way as you clean the operating rooms. Damp dust all horizontal surfaces with a germicidal solution, paying particular attention to counter tops, open shelves, and the tops of cabinets. Also, damp dust horizontal surfaces on all sterilizers and sterilizer related equipment, and warming cabinets. This includes cabinet tops, control panel surfaces, door rims, door handles, and any racks or carts exposed to airborne contamination. After all damp-dusting has been completed:

- Apply detergent germicide solution to the floors and proceed to wet-vacuum.
- Damp dust the equipment with a clean, lint-free cloth moistened with an EPA registered hospital detergent before being brought into the surgical suite and designated operating rooms. It should also be checked for functionality prior to the start of any surgical procedure.

NOTE: Consult the manufacturer’s recommendations prior to using cleaning solutions. Cover items that cannot be cleaned with a moisture-impervious protective covering that can be cleaned or discarded after each use.

During-case activities

During the surgical procedure, the goal of sanitation activities is to confine and contain contamination to as limited an area as possible.

As a circulating technician, there are several measures you should take to confine the spread of contamination during a procedure.

- Use a detergent-germicide solution to immediately “spot-clean” any area that is contaminated with blood, body fluids, or other organic matter. You may use a small squeeze bottle to apply

the solution, then a rag to mop it up, or you may simply use a rag soaked in germicidal agent. *Always wear gloves when spot cleaning contaminated areas*.

- Keep all soiled surgical sponges contained and sealed in impervious containers such as plastic bags. Once again, always wear gloves when handling soiled, bloody sponges to prevent exposure to blood-borne pathogens.
- Avoid contaminating the outside of specimen containers; if they do become contaminated, disinfect them with germicidal solution before they are removed from the operating room.Also avoid contaminating x-rays, lab slips, and patient documentation; ensure you never handle these items with contaminated gloves.

As a scrub technician, you can best help contain contamination by exercising caution when handling and disposing of contaminated items.Be careful not to drop organic matter on the floor. *Do not* "toss" soiled sponges into the kickbucket; drop them as gently as possible to avoid spraying contaminated droplets around the room. When passing a tissue specimen or culture, do not contaminate the outside of the container. Keep the cut-off ends of suture contained in a sterile trash container; dropping them on the floor or letting them get tangled in sponges scatters the contamination. Avoid splashing irrigation solution, and also avoid splashing when cleaning instruments on the sterile field. Remember, the goal is to keep the contamination confined to as small an area as possible during the procedure.

After-case activities

All surgical wounds, regardless of their classification, are potential sources of contamination. Therefore, all surgical cases are considered contaminated, and the operating room should be cleaned as such. Immediately after the procedure, when the patient has been transported to a postoperative care unit, the room must be readied for the next patient. The ultimate goal of between-case cleaning is to contain, confine, and destroy potentially infectious microorganisms to prevent cross contamination of patients and personnel.The scrub and circulator, together with other available surgical and housekeeping personnel, work as a team to clean the room. This cleaning must be done swiftly, but effectively. Never cut corners during between-case cleaning; a "room turnover" must not be done in a manner that compromises patient or personnel safety.

Scrub technicians normally handle all contaminated items after the surgical procedure because they are protected by the gown, gloves, and other attire.Circulators perform cleanup activities that generally do **not** involve direct contact with contaminated items. However, wearing of gloves by the circulator to prevent skin contact with possible pathogens is recommended.

Scrub duties

As a scrub technician, your first task is to "break-down" the sterile field. This generally involves:

- Separating (disposable from reusable) surgical drapes and linens that were used on the patient, and placing them in appropriate containers (trash vs. linen). This includes not only the drapes used during the procedure, but also the sheets used to make the OR bed and any positioning aids that were used.
- Cleaning gross blood and organic matter from all instruments; if blood or organic matter is visible, it is considered gross contamination. While still protected by the gown, gloves, eyewear or face shield, and other protective attire, you should remove as much visible organic matter as possible from all instruments. Usually, this is done by:
    (1) Opening and/or dismantling the instruments and allowing them to soak in a large basin to loosen the soil.
    (2) Using a sponge or soft brush to remove the stubborn debris.
    (3) Placing the instruments in a wire or mesh basket (or instrument pan) after removing the gross soil.

(4) Flushing all cannulated/lumen instruments and place instruments in wire baskets with heavy instruments on the bottom and delicate on top.

NOTE: Clean reusable sharp instruments individually and separately, using extreme caution to prevent injury or compromise of your protective barriers.

Place the sharps in highly visible area of the instrument basket, or place them in a separate container. Clean the instruments; then place them in the containers in this manner to prevent instrument reprocessing personnel from having to manually wash or otherwise handle contaminated items before they are decontaminated.

- Placing the basket in a puncture-resistant container which is leak-proof on the bottom and sides. Then isolate this container from clean items and transport it to the reprocessing area as directed by local policy. Since all items opened during a procedure are considered contaminated, all instruments in the set are handled and transported in this fashion, even if they were not actually used.
- Gathering all contaminated disposable items such as gowns and gloves, drapes, sponges, suture fragments, suction tubing, etc., and discarding them in a sealable, leak-proof, container or plastic bag. You may use the disposable back-table cover and other furniture drapes to roll up smaller contaminated items; then discard them in the container. The container should be color coded or clearly labeled.

  NOTE: Never place needles and blades with other disposable surgical trash. Place them in specially designed disposal containers (magnetic or self-closing adhesive pads) and then dispose of them in an appropriate container per local policy.
- Collecting and discarding all soiled, reusable linen items such as hand towels and pillow cases from the back table and other furniture, into a sealable, leak-proof, container or plastic bag. The container should be color coded or clearly labeled.
- Handling other contaminated items; collecting and discarding disposable anesthesia circuits, masks, breathing bags, and suction tubing; and disposing of suction containers and their contents.

When all contaminated items are properly contained, but before the containers are sealed, you may remove your gown and gloves. As you remove them, ensure you avoid touching the contaminated areas by turning the gown inside-out and rolling it with the contaminated side on the inside of the bundle. You then remove the gloves by turning them inside out, touching only the skin-side surfaces. Discard them in the appropriate container(s), then seal all containers and remove them from the room. Wash your hands!

Circulator duties

While the scrub is breaking down the instrument setup and disposing of the contaminated trash and linen, the circulator, and/or other OR staff members, are performing other tasks. Even if local policy does not require you to do so, it is a good idea to wear protective gloves and eyewear when performing these duties. As a circulating technician you perform tasks such as:

- Disconnecting the non-contaminated ends of cords, tubing, and similar items from the electrosurgical generator, suction units, video equipment, and other nonsterile equipment.
- Dismantling or disconnecting nonsterile equipment, and removing it from the operating room. Wipe down all equipment with a detergent-germicide before removing it from the room.
- Collecting and returning all unopened sterile supplies to storage.

Assist the scrub as necessary. Any area the scrub touches becomes contaminated, so you (the circulator) should do any task that would require the scrub to touch a surface non-protected personnel may come in contact with. Touching only the “clean” areas; open the containers for

transporting instruments, replace full trash or linen containers with fresh ones, open the decontaminator or washer-sterilizer (if local policy dictates their use), and disconnect the suction containers from wall suction to allow disposal. When the scrub is ready, help remove the contaminated gown by unfastening the neck and back ties as needed.

After these initial case breakdown steps are done, remove the trash and linen containers from the room and transport them to the locally designated area. Transport the instrument containers to the decontamination area of the reprocessing area (usually Sterile Processing and Distribution). Then, begin cleaning the operating room. The method you use to clean the room usually depends upon whether the room will be used for a "to-follow" procedure or between-case cleaning, or whether the room is ready for "end-of-day" cleaning.

Between-case cleaning

Usually, several people, including housekeeping personnel, work as a team to help finish the between-case cleaning, and to prepare the room for the next case. Most of the cleaning efforts concentrate on grossly soiled areas. These are some of the final steps of between-case cleaning:

- Use a detergent-germicide solution to damp-dust horizontal surfaces of overhead lights and other surgical furniture and equipment used during the procedure. Pay particular attention to the operating bed, nearby IV poles, suction apparatus, and kick buckets. Ensure you completely remove all blood and organic materials.
- Spot-clean contaminated areas of walls, cabinets, and other environmental surfaces as necessary.
- Spray or sprinkle floors with a detergent-germicide solution. Local policy determines how much of the floor is routinely cleaned between cases. Current recommended practices state,

  > "For end-of-case cleaning (between-case cleaning), it is only necessary to clean a 3- to 4-foot perimeter around the operative site. The area cleaned is extended as necessary to adjacent areas of contamination. Use a wet-vacuum to pick up the solution. Also, pick up and dispose of any suture fragments missed by the vacuum."

NOTE: Some guidelines recommend using a mop to spread the germicidal solution and to provide mechanical action to remove gross soil.

If your facility allows the use of mops, you must use fresh detergent and a clean mop head for each procedure. A wet-vacuum is used to pick up the solution after mopping.

- Replace kick bucket liners, suction bottles, suction tubing, and OR bed linen.
- Wash your hands before starting other activities.

The steps outlined above (except for washing your hands—you always do this) may differ from those used in your operating room due to limitations imposed by the physical layout of the *or*, types of supplies you use, and types of cleaning and sterilizing methods available. This information is presented as a guideline. In between cases, equipment should be wiped down with a germicide solution and stored properly so that it is prepared for the next use. Refer to your local policies, procedures, and operating instructions for specific between-case cleaning activities.

End-of-day cleaning

At the end of the day's schedule, the operating rooms, sub-sterile areas, scrub areas, hallways, and other areas of the surgical suite are terminally cleaned. All furniture and equipment in the operating rooms are also thoroughly cleaned at the end of each duty day. Some of the particular tasks of end-of-day cleaning include:

- Moving furniture away from the walls and cleaning the lower walls with detergent-germicide solution.

- Washing all furniture and equipment. Start at the center-most, highest point (usually the OR lights), and work outward in a spiral pattern. Pay particular attention to the base of the operating table and intravenous (IV) stands. IV solutions and blood often drip onto the lower part of the IV stands, and the OR table is prone to splattering from prep and irrigation solutions, body drainage, and dropped sponges.
- Cleaning the casters on wheeled furniture, including removing all suture strands.
- Cleaning all equipment, such as operating lights, portable lights, electrosurgical units, and suction machines.
- Damp-dusting cabinets, doors, and windows.
- Cleaning the sinks, plumbing fixtures, and walls of the scrub and sub-sterile rooms.
- Cleaning the entire floor with tuberculocidal detergent-germicide. A common method of cleaning the floor involves:
    (1) Moving all furniture to one side of the room, wetting the floor on the empty side, then moving all furniture to the wet side and wetting the other half of the floor.
    (2) Allowing the solution to work for a few minutes, then using a mechanical scrubbing device such as a brush, mop, or electric scrubber, loosen the soil. Specially designed machines, with scrubbing and spraying devices, are also available.
    (3) Using a wet vacuum to remove the solution from the floor. The wet vacuum is used because it picks-up soil and microbes suspended in the solution, preventing them from drying on the surfaces. It also helps ensure the removal of dirty solution from cracks, crevices, and corners.
    (4) Returning furniture to its proper position in the room.
- Cleaning the ancillary areas of the surgical suite in the same manner as the operating room is cleaned.

Though not technically part of cleaning, you may also be required to “re-stock” all used supplies in the operating rooms and ancillary areas. When you do so, ensure you inform your supervisor, noncommissioned officer in charge (NCOIC), or whoever is the staff member “in-charge” of end-of-day activities.

Periodic cleaning activities

To anyone except experienced operating room personnel, the cleaning measures just described would be considered to result in ultimate cleanliness. But in the surgical environment, this daily cleaning has shortcomings. We correct these gaps by conducting periodic cleaning; some of this cleaning is done once a week, some less frequently.

The areas cleaned on a weekly or on a less frequent basis are most likely determined by your OR supervisor, NCOIC, housekeeping staff, and infection control nurse. Usually, you perform periodic cleaning of items and areas in the surgical suite that are not normally cleaned at the end of each day. This generally includes tasks such as:

- Washing all walls from ceiling to floor.
- Vacuuming or otherwise cleaning air exchanger covers or grills.
- Cleaning the inside and outside of all storage cabinets.
- Cleaning the chambers of all warming cabinets.
- Cleaning sterilizer chambers and flushing the drains.
- Vacuuming solution from plaster traps.
- Cleaning and restocking burn, crash, and cast carts, if present.
- Defrosting and thoroughly cleaning refrigerators.

- Cleaning and disinfecting refillable soap dispensers.
- Damp dusting equipment with a clean, lint-free cloth moistened with an EPA-registered hospital detergent

There are many other areas or items that require cleaning in the surgical environment. Since every surgical suite is configured differently, and since the type of equipment and frequency of use varies greatly, local policies guide you in how and when these areas are cleaned (also who cleans them). The important thing to remember is that everything that may contact a patient should be first cleaned to reduce the likelihood of contamination and subsequent infection.

Summary

This section covered a lot of information on basic infection control measures. It started with covering personal hygiene and handwashing, then covered the special attire we wear to protect our patients and ourselves from pathogens. The final section covered basic sanitation and housekeeping measures employed in most operating rooms. Before you move on to the more in-depth measures we use in surgery, ensure you have a thorough knowledge of these infection control basics by answering the following questions.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

207. Personal hygiene and surgical attire

1. List some of the personal hygiene recommendations for fingernails.

2. List some of the restrictions for wearing jewelry in the operating room.

3. What is the mode of transmission for most preventable nosocomial infections?

4. Contrast the purpose of routine hand-washing with that of the surgical scrub.

5. What agent is recommended by the CDC for routine handwashing?

6. Describe the steps of proper handwashing technique.

7. What is the purpose of surgical attire?

8. When should you don your surgical cap or hood?

9. List two reasons surgical attire should not be laundered at home.

10. What type of top or jacket should non-scrubbed personnel wear? Why?

11. List some of the criteria for surgical footwear.

12. When should you wear shoe covers?

13. Why should you not “double mask”?

14. Describe the proper way to remove a surgical mask.

15. For what type of surgical procedures is protective eyewear or a face shield required?

16. What is the purpose of wearing a nonsterile gown?

17. Ideally, if you wear surgical attire out of the department, what should you do on return?

208. Sanitation and housekeeping

1. What is the primary purpose of all operating room sanitation activities?

2. Describe the steps to start-of-day cleaning.

3. What is the goal of sanitation activities performed during a surgical procedure?

4. List three measures a circulator should take during a case to limit the spread of infectious agents.

5. How can the scrub best help contain contamination during the surgical procedure?

6. What is the ultimate goal of between-case cleaning?

7. Which surgical team members routinely handle all contaminated items after a procedure? Why?

8. List some of the steps involved as the scrub technician “breaks-down” the sterile set-up.

9. Where are most of the between-case cleaning efforts concentrated?

10. List five activities associated with the actual cleaning of the OR between cases.

11. At the end of the day, what areas in the scrub room are cleaned?

12. Generally, what items and areas in the surgical suite are cleaned periodically?

Answers to Self-Test Questions

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1. To identify and reduce the risks of *acquiring* and *transmitting* nosocomial infections among patients, employees, physicians and other independent licensed practitioners, contract service workers, volunteers, students, and visitors.
2. The CDC.3. Local, state, and federal public health services; the EPA; OSHA; AAAHC; JC; AST; the American College of Surgeons; and the AORN.
4. The executive committee of the medical staff.
5. Must be an officer or civilian equivalent with a minimum of three years clinical experience in their field (i.e., nursing, dental, lab, public health, and medical).

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1. Surveillance/reporting and prevention/control.
2. Collect detailed information on all patient infections encountered in our hospitals. Monitor the infection rates of different services, individual units, and other specific areas.
3. Any wound that drains purulent materials, or when the surgeon diagnoses it as infected.
4. At the end of the procedure.
5. Class I–clean wound.
6. Dirty or infected wounds are old, traumatic wounds containing areas of dead tissue, evidence of gross intestinal content spillage, or infection.
7. Blood; all body fluids, including secretions and excretions; non-intact skin; and mucous membranes.
8. (1) After touching blood, body fluids, secretions, excretions, and contaminated items, *even if you were wearing gloves.*

(2) After removing gloves, between all patient contacts, and whenever you may potentially transfer microbes to other patients or areas.

9. (1) When touching blood, body fluids, secretions, excretions, and contaminated items.
   (2) Before touching mucous membranes or non-intact skin.
   (3) Remove gloves immediately after use and *before touching non-contaminated items or surfaces.*
   (4) Put on fresh gloves before going to another patient.
10. A mask and eye protection or face shield.
11. Never recap used needles or otherwise manipulate them using both hands, or any other technique that involves directing the point of a needle toward any part of the body. Use either a one-hand "scoop" technique or a mechanical device designed for holding the needle sheath. Do not remove needles from disposable syringes by hand, and do not bend, break, or otherwise manipulate used needles by hand. Place used disposable syringes and needles, scalpel blades, and other sharp items in appropriate puncture resistant containers located as close as practical to the area in which the items were used. Place reusable syringes, needles, and other sharp items in a puncture- resistant container for transport to the reprocessing area.
12. Airborne, droplet, and contact.

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1. Nails should be relatively short; nail polish should not be worn; artificial nails are forbidden.
2. Wearing of jewelry in the operating room is not recommended. If permitted, it must be contained inside (under) normal surgical attire. Circulators may wear a watch and a ring, but they must be removed for hand washing. Hand and wrist jewelry must also be removed anytime gloves are donned. Scrub personnel may not wear any jewelry on the hands and arms.
3. Hospital personnel.
4. Hand washing is done to remove the contaminants your hands pick up from various sources to keep them from contaminating the rest of your body or other things you touch. In contrast, the surgical scrub is done to remove transient and resident bacteria from your hands and arms to minimize the chances that you will infect a patient.
5. Plain soap (no antiseptic required).
6. (1) Remove all jewelry - including rings and watches.
   (2) Expose forearms – remove or roll up long sleeves.
   (3) Turn on and adjust the water - protect the controls by using a paper towel or similar barrier; adjust the water temperature (if possible) so it is comfortably warm and the flow is slow and steady.
   (4) Develop lather - wet your hands thoroughly; lather them to just above the wrists; keep your hands *lower* than your arms to prevent the contaminated soap and water from running up the cleaner areas of your arms.
   (5) Scrub hands - rub your hands together, using small circular motions; clean all areas of your hands, including the hard-to-reach areas between the fingers; re-lather hands as necessary to ensure you have plenty of suds; scrub the hands vigorously for at least 10 seconds.
   (6) Clean nails - if this is the first wash of the day, or if your hands are grossly soiled, clean your fingernails with a nail file or disposable nail cleaner; use the same technique as for the surgical scrub; clean nails under running water to flush the contaminants down the drain.
   (7) Rinse - keep your hands below your elbows to allow the contaminated soap and water to run off your fingertips; if you used bar soap, rinse off the bar and put it back in the soap dish just before rinsing your hands; avoid touching the soap dish and sink surfaces—they are probably more contaminated than your now clean hands.
   (8) Dry - dry your hands thoroughly, using either paper or single-use cloth towels.
   (9) Turn off water - if you must use your hands, protect them with a paper towel.
   (10) Skin care - if hands are chapped or skin is dry, use hand lotion to soften skin and reduce shedding of dead skin cells.
7. To help protect patients from infection and protect staff from contamination.
8. Before the scrub suit and other attire.

9. It may lead to the spread of microorganisms in the home, and its care cannot be adequately controlled to protect the surgical environment.
10. Long-sleeved, elastic cuffed, jackets that are snapped or buttoned during use.
11. Shoes should be dedicated solely for the operating room, washable, comfortable, provide good support, and be protective.
12. When dedicated shoes are not available, when exposure to blood or body fluids may be expected, and to cover your dedicated shoes when you leave the OR.
13. It acts as a barrier rather than a filter.
14. Untie and handle the mask only by the strings; never touch the mask body; discard the mask immediately; wash hands.
15. All surgical procedures.
16. To protect you from pathogenic contaminants.
18. Completely change.

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1. Reduce and control the possibility of cross-contamination between patients and surgical staff members by reducing the number of microorganisms in the surgical environment.
2. (1) Remove unnecessary furniture and equipment.
   (2) Damp dust all horizontal surfaces in the operating room, starting with the highest, most central point in the room, and working downward and outward in a spiral pattern.
   (3) Move all mobile furniture to one side of the room.
   (4) Apply detergent germicide solution to the bare floor, then roll all movable furniture onto the now wet floor and apply the solution to the other side. Use a wet-vacuum to pick up the solution
3. To confine and contain contamination to as limited an area as possible.
4. (1) Use a detergent-germicide solution to immediately “spot-clean” any area that is contaminated with blood, body fluids, or other organic matter.
   (2) Keep all soiled surgical sponges contained and sealed in impervious containers such as plastic bags.
   (3) Avoid contaminating the outside of specimen containers, x-rays, lab slips, and patient documentation.
5. Exercise caution when handling and disposing of contaminated items.
6. To contain, confine, and destroy potentially infectious microorganisms to prevent cross contamination of patients and personnel.
7. Scrub technicians; they are protected by the gown, gloves, and other attire.
8. (1) Separating (disposable from reusable) surgical drapes and linens that were used on the patient, and placing them in appropriate containers (trash vs. linen).
   (2) Cleaning gross blood and organic matter from all instruments, then placing them in pans or baskets in a manner that prevents instrument reprocessing personnel from having to manually wash or otherwise handle contaminated items before they are decontaminated.
   (3) Placing the basket in a puncture-resistant container, leak-proof on the bottom and sides, for transport to the processing area.
   (4) Gathering all contaminated disposable items and discarding them in a sealable, leak-proof, container or plastic bag.
   (5) Collecting and discarding all soiled, reusable linen items, such as hand towels and pillow cases from the back table and other furniture, into a sealable, leak-proof, container or plastic bag.
   (6) Handling other contaminated items; collecting and discarding disposable anesthesia circuits, masks, breathing bags, and suction tubing; and disposing of suction containers and their contents.
9. On grossly soiled areas.
10. (1) Use a detergent-germicide solution to damp-dust horizontal surfaces of overhead lights and other surgical furniture and equipment used during the procedure.
    (2) Spot-clean contaminated areas of walls, cabinets, and other environmental surfaces as necessary.
    (3) Spray or sprinkle floors with a detergent-germicide solution.

(4) Pick up and dispose of any suture fragments missed by the vacuum.

(5) Replace kick bucket liners, suction bottles, suction tubing, and OR bed linen.

11. The sinks, plumbing fixtures, and walls.
12. Items and areas in the surgical suite that are not normally cleaned at the end of each day.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

Do not return your answer sheet to AFCDA.

20. (205) What U.S. Public Health Agency provides valuable information to hospitals outlining how infection control programs should be developed and operated?
    a. Centers for Disease Control and Prevention (CDC).
    b. Association of periOperative Registered Nurses (AORN).
    c. Association for the Advancement of Medical Instrumentation (AAMI).
    d. The Joint Commission (TJC).

21. (205) As a *minimum*, how often must area-specific operating instructions (OI) for infection control be reviewed?
    a. Every six months.
    b. Annually.
    c. Every two years.
    d. Every three years.

22. (206) What infection control activity includes data collection and analysis?
    a. Control.
    b. Reporting.
    c. Prevention.
    d. Surveillance.

23. (206) The Centers for Disease Control and Prevention (CDC) surgical wound classification should be assigned at the
    a. end of each surgical procedure.
    b. beginning of each surgical procedure.
    c. end of elective (scheduled) surgical procedures only.
    d. beginning of elective (scheduled) surgical procedures only.

24. (206) When must standard infection precautions be used?
    a. All surgical procedures.
    b. Centers for Disease Control and Prevention (CDC) class II, clean-contaminated surgical procedures only.
    c. CDC class III, contaminated surgical procedures only.
    d. CDC class IV, dirty or infected surgical procedures only.

25. (207) Which of the following statements is an accurate recommendation for the wear of jewelry in the operating room?
    a. Wearing of jewelry is strictly prohibited.
    b. When jewelry is worn, it must be clearly visible.
    c. When jewelry is worn, it must be contained inside surgical attire.
    d. The only jewelry that may be worn by scrubbed personnel is a watch and two rings.

26. (207) What cleansing agent is recommended by the Centers for Disease Control and Prevention (CDC) for routine hand-washing?
    a. Plain soap.
    b. Povidone-iodine.
    c. Phenolic detergent.
    d. Chlorhexidine gluconate.

27. (207) *Non-scrubbed* personnel should routinely wear
    a. a non-sterile, disposable gown.
    b. long-sleeved, elastic-cuffed jackets.
    c. an impervious jumpsuit or coveralls.
    d. an impervious plastic apron or gown.

28. (207) As a minimum, surgical masks should be changed
    a. once a day.
    b. twice a day.
    c. every two hours.
    d. between each case.

29. (208) Why *shouldn't* you use a solution of 70 percent isopropyl alcohol for cleaning furniture in a surgical suite?
    a. It evaporates quickly.
    b. It is not an effective germicide.
    c. Prolonged use can damage surgical equipment.
    d. It reduces the possibility of cross-contamination.

30. (208) Why is an operating room cleaned at the start of the day before the first patient is brought in?
    a. To remove any settled dust.
    b. To remove any gross contamination.
    c. To confine the spread of contamination.
    d. To reduce the possible source of wound contamination.

31. (208) What *must all* personnel involved with between-case cleaning activities do *before starting any* other activities?
    a. Don clean surgical gloves.
    b. Thoroughly wash their hands.
    c. Change into clean surgical attire.
    d. Open the sterile supplies for the next procedure.

Please read the unit menu for unit 3 and continue ➔

Student Notes

Unit 3. Cleaning, Assembling, and Packaging Reusable Items

THE INSTRUMENTS AND SUPPLIES used in your operating room (OR) are very expensive. They represent a significant expenditure of taxpayer's dollars and account for a large portion of your hospital's annual operating budget. You may have noticed many of the supplies you use are disposable and should not be cleaned or reprocessed. They are called single-use items; they are used on one patient and thrown in the trash. However, some of the supplies and the majority of surgical instruments are designed to be used over and over. Instruments, in particular, are very expensive, often delicate, and easily damaged. If they are not cleaned and handled properly, their useful life expectancy is significantly reduced, no matter how durable they appear to be.

In this age of budget cutbacks and decreasing military spending, the Air Force can not afford to constantly replace expensive surgical instruments and supplies. Moreover, every instrument or durable supply item damaged due to improper use or care reduces your unit's medical mission capability. Surgeons rely on the availability of these supplies and surgical tools to provide the best surgical patient care possible; if you damage one of their essential tools, the patient may suffer.

In addition to conserving resources and maintaining mission capability, proper care and handling of surgical items helps reduce the risk of patient injury and infection. A properly cleaned and processed instrument is a safe instrument for the patient. An improperly cleaned and processed instrument is potentially deadly.

Processing surgical instruments and supplies is a very important part of your job. In fact, you will probably discover that a major portion of your duty time is devoted to various instrument processing and supply activities. The information presented in this unit will help you learn how to properly clean, assemble, and package surgical instruments and supplies.

3–1. Cleaning, Inspecting, and Assembling Surgical Instruments

To prevent the spread of infectious microorganisms in the environment to staff members and among surgical patients, all reusable supplies and instruments are thoroughly decontaminated and cleaned before they are sterilized and reused. The cleaning method chosen has to be economical, non-damaging to the items being processed, and provide protection for surgical personnel and patients from injury and infection.

Proper decontamination and cleaning lays the groundwork for final sterilization and disinfection of patient care items. Never take shortcuts when cleaning instruments or supplies; otherwise you jeopardize the health and safety of your patients and co-workers. Careless cleaning can also result in damage to expensive, often delicate, surgical items.

This section introduces basic processing terminology and the various methods used to decontaminate and clean instruments and supplies. It also covers some basic principles relating to care and handling of surgical instruments.

209. The process of cleaning and decontamination

To fully understand cleaning procedures used in surgery and sterile processing, you must first become familiar with some basic terms and how they apply to the overall instrument processing and supply cycle.

Cleaning

The term “cleaning” is used to refer to many activities in the surgical environment. The exact action varies according to what, where, and how the cleaning is accomplished. In the context of instrument and supply processing, *cleaning* is defined as “the physical removal of organic material or soil from an object.”Cleaning is designed to remove, rather than destroy, microorganisms. Cleaning is a key element in the instrument reprocessing chain, and it is generally performed in stages. The most common stages are initial cleaning of gross (visible) contaminants, pre-soaking (or pre-rinsing), then either mechanical or manual cleaning before being decontaminated.

1. *Initial cleaning* –Initial cleaning is the first step in reprocessing; it is essential that it begin in the OR by the scrub technician *before* items are sent to the decontamination/reprocessing area. All gross contaminants should be cleaned from instruments and reusable items. Additionally, items with lumens or cannulas should be thoroughly flushed until the fluid emerges clear.
2. *Pre-soaking or pre-rinsing* –Pre-soaking or pre-rinsing is used to prevent blood and other organic matter from drying and adhering to the instruments, or loosen dried blood and organic matter. Some facilities simply use water for the presoak, others use water mixed with an agent to help remove the soil. The agent used may be an “enzymatic” liquid that helps clean instruments by dissolving the enzymes of the organic matter, or the agent may be a detergent.
3. *Mechanical vs. manual cleaning* –Mechanical cleaning is performed in a machine, generally either a washer-sterilizer or washer-decontaminator. It is the method of choice because it minimizes exposure of personnel to potential pathogens. Manual cleaning is simply hand washing of items by reprocessing area personnel; use it only if mechanical cleaning is *not* feasible.

Decontamination

According to OSHA, decontamination is defined as:

> The use of physical or chemical means to remove, inactivate, or destroy bloodborne pathogens on a surface or item to the point where they are no longer capable of transmitting infectious particles, and the surface or item is rendered safe for handling, use, or disposal.

The two methods we use most frequently to decontaminate items are disinfection and sterilization.

Disinfection

Disinfection is one method that can be used to decontaminate items; it is the process of destroying or inhibiting the growth of microorganisms. Disinfection is clearly differentiated from sterilization since disinfection *does not* kill all microorganisms. Chemical disinfection is often used to decontaminate items that are too delicate to withstand a sterilization process. A disinfectant is used if sterilization is not feasible. We talk about disinfection in greater detail later.

Sterilization

Sterilization is a process that results in the *total destruction of all microorganisms* (including spores). When this method is used in the decontamination process, it is often referred to as *terminal sterilization*. When we say an item has been terminally sterilized, we mean that it has been sterilized to decontaminate it and make it biologically safe for handling and reprocessing. Terminal sterilization is *not an end process*—an item that has been terminally sterilized must be subjected to other

processes, such as final sterilization, before it is safe for use on a patient. We elaborate more on sterilization later.

Knowing the terms is a start, but to ensure instruments and supplies are adequately and safely cleaned and decontaminated, you must be familiar with the methods used.

NOTE: As you study the following material, remember that cleaning must not be confused with decontamination. *Cleaning does not render the items biologically safe for handling.*

Initial cleaning and handling

The cleaning process actually begins in the OR during the surgical procedure. The scrub technician cleans as much visible organic matter (called gross contaminants) from all instruments and supplies. Removing gross contaminants during the procedure is done by wiping instruments with a wet sponge or towel. If the scrub cannot clean the instruments immediately after retrieving them from the field, then soaking the instruments in a basin of sterile water, or other locally approved solution, will keep the organic material from drying until it can be wiped from the instrument.It is also during this initial cleaning process that items with lumens or cannulas are thoroughly flushed until the fluid emerges clear.

After the surgical procedure, the scrub technician continues to clean the gross contaminants from all instruments and reusable supplies as he or she is “breaking-down” the sterile set-up. This cleaning is accomplished at the back table and basin or ring stands ***before*** the scrub removes his or her gown, gloves, and other protective attire. Removal of gross contaminants is *not* routinely done in the OR substerile or utility areas.

After gross contaminants are removed, all instruments are gathered and placed in leak-proof (on the bottom and sides) containers. Sharp instruments and any instrument that may puncture, lacerate, or otherwise injure somebody *must* be placed in the containers in a manner that ensures that the person in the decontamination area *does not have to reach into the container to retrieve them.* When all instruments are consolidated into the appropriate pans or containers, they are transported to the decontamination area, usually located in Sterile Processing and Distribution (SPD). Depending on local policy, the contaminated instruments may be transported in dry, puncture-resistant containers, or they may be transported in a container with a pre-soaking agent. The containers should be transported in plastic bags or other moisture-proof containers. This not only confines the microorganisms, but also helps prevent organic matter from drying on the instruments.

Pre-soaking/pre-rinsing

Pre-soaking or pre-rinsing is an optional phase of the cleaning process, but is highly recommended. As stated previously, the purpose of the presoak or pre-rinse is to help loosen dried blood and organic matter the scrub technician missed. The presoak also helps prevent these organic substances from drying on the instruments. The presoak may be started in the OR immediately before the instruments are transferred, or it may be done after they are received in the decontamination area.

Pre-soaking or pre-rinsing is simply immersing the instruments and other contaminated items in a solution before subjecting them to manual or mechanical cleansing. Many solutions are available for use as a presoak. Some facilities simply use distilled water; others use enzymatic solutions which help remove organic matter by dissolving proteins—even in hard-to-reach areas such as lumens. Detergent solutions help loosen the bonds between the item and the contaminants by suspending the contaminants in solution. Dual solutions are also available; they offer a “two-front-attack” by combining an enzymatic with a detergent.

Whether or not a presoak/pre-rinse solution is used, the items should be immersed only for a relatively short time. The solution container’s label usually provides detailed instructions for mixing and using it—follow them! Mixing an agent with a weak concentration may not clean effectively; one too strong may damage the items being soaked or rinsed. Saline should not be used as a soaking

solution. The salt will eventually pit the metal on the instrument, permanently damaging the instrument and leading to the formation of rust.

Manual cleaning and decontamination

Manual cleaning is simply cleaning done by hand-washing the items. While this method is initially used to remove gross contaminants in the OR, the majority of the post-surgical manual cleaning should routinely be done in the central decontamination area (not in the OR). Manual cleaning of medical and surgical instruments and supplies is the *least safe* and *least efficient* cleaning method, but it is unavoidable in some situations. *Use it only when no other method is available*. When you have no alternative, but to manually clean contaminated instruments or other items, you must follow some rules and take certain precautions. Some of these are included in the following table.

Rules and Precautions for Manual Cleaning of Contaminated Instruments

Rule/Precaution	Amplification
Wear all personal protective equipment (PPE) required by the Occupational Safety and Health Administration (OSHA) and the Centers for Disease Control and Prevention (CDC).	• Eye and face protection. A full-face shield is recommended. • A surgical face mask. A high filtration mask is recommended. • A surgical cap or other permitted hair cover. • A scrub suit, covered with a liquid-proof gown or apron with long, impervious sleeves. • A moisture-resistant coverall or similar item is also recommended if spills or splashing is likely. • Rubber or latex gloves. They should be high enough and strong enough to prevent contact with the solution. • Water-proof boots or shoe covers should be worn if splashing or fluid pooling on the floor is likely.
Wash the items in clean, warm water, mixed with a detergent that is non-corrosive, low sudsing, and that will leave no residue.	• Liquid solutions are generally preferred over powders because they are non-abrasive and disperse more evenly in water. Never use non-diluted detergent to clean instruments unless the manufacturer and local policy specifically allow you to do so. • Use a pH-neutral (7.0) detergent. Alkaline detergents stain instruments; acid solutions cause corrosion or pitting (etching). • Dual-purpose solutions, such as those discussed for pre-soaking, may also be used for manual cleaning.
Keep all items immersed in, and guard against splashing of, the solution while manually washing items.	• Prevents microbes from being transmitted via airborne droplets (this is known as aerosolization). • Use a soft-bristle brush to clean the box locks, ratchets, serrations, and other hard-to-reach places on instruments and glassware. Never use steel wool, abrasive pads, or other abrasive agents to routinely scrub surgical instruments. Abrasives ruin the finish and lead to corrosion of the instruments. • Clean delicate microsurgery instruments, such as those used for eye or neurosurgery, according to the manufacturer's directions. Many allow you to use a soft-bristle brush to wash them, and a clean cotton cloth to wipe them dry after rinsing. However, some microsurgical instruments have fine tips or teeth that may be damaged simply by wiping them with a sponge. Always pick delicate instruments up by their handles, and do not allow them to strike each other or other objects as you clean them. **NOTE:** Some items cannot be immersed, such as air-powered instruments.

Rules and Precautions for Manual Cleaning of Contaminated Instruments	
Rule/Precaution	**Amplification**
Clean air-powered instruments according to the manufacturer's directions.	• Do not immerse the motor in liquid. Most air-powered handpieces cannot be submerged in a basin or cleaned in a mechanical device (discussed later). The motor is cleaned with a disinfectant-soaked soft cloth, and then rinsed using a water-soaked cloth, then dried. • Leave the air hose connected to the handpiece during cleaning. This reduces the likelihood of solution entering the motor. • Disassemble all accessories and attachments before cleaning. Some attachments may be mechanically cleaned, others may not. • Lubricate all components according to manufacturer's directions; some require you to operate the instruments after lubricating them. **NOTE:** These directions vary greatly from manufacturer to manufacturer, and even from item to item, so be very careful to use the specific directions for the specific item you are cleaning.
Rinse all items thoroughly with hot water to remove all residual detergent and other matter; then allow the instruments to dry.	• Rinsing with hot water allows the residual heat in the rinsed items to speed up the drying process. • Do not leave items laying on damp or wet surfaces. • Do not place items in non-sterile storage until they are completely dry. • Doing so leads to instrument spotting, staining, and rusting.
Place instruments in appropriate containers for terminal sterilization (if the instrument is heat and moisture tolerant) or for chemical disinfection according to local policy.	• Metal and other heat and moisture tolerant items may be terminally sterilized; ideally, they are processed in a mechanical disinfecting device such as a washer-sterilizer. • Lensed instruments may require high-level disinfection; ideally they are processed in a mechanical disinfecting device such as a peracetic acid sterilizer.

Before moving on to mechanical cleaning devices, a few points need to be stressed. *Manual cleaning* of medical instruments and supplies *is not recommended* because it poses a health hazard to processing personnel. It is also time-consuming, difficult to accomplish, and *does not* usually render the item biologically safe for handling. Generally, manual cleaning is *not* as thorough as mechanical cleaning, particularly for items with hard-to-reach places such as lumens. When mechanical cleaning devices are available and appropriate—use them!

Mechanical cleaning and decontamination

Mechanical cleaning is the recommended method for all surgical instruments and other supplies. Mechanically removing the bioburden and rendering the item safe for handling greatly reduces health risks to processing personnel because handling of the contaminated items is minimal. However, mechanical cleaning devices rely on one very important factor—gross contaminants and organic debris must be removed from the items before they are put in the machines. This is why it is so important that the scrub technician cleans gross contaminants from the instruments in the operating room.

Mechanical cleaning devices

There are primarily three types of machines used to mechanically clean instruments and other reusable supplies—washer-sterilizers, washer-decontaminators, and ultrasonic cleaners.

Washer-sterilizers

The washer-sterilizer does what the name implies; it washes the contaminated items, and then terminally sterilizes them. The wash is usually done by filling the chamber with solution, then agitating the solution. Some washer-sterilizers are more effective than others. (The specific operating

cycles of a washer-sterilizer are covered under steam sterilization.) Here we concentrate on how this piece of equipment is used in the cleaning and decontamination phase of reusable item processing.

Ideally, you process all contaminated items that are not damaged by heat and moisture through the washer-sterilizer immediately after use. This accomplishes two things: (1) it finishes what the scrub technician's initial manual cleaning began and further removes soil from the surfaces of instruments and supplies, and (2) it terminally sterilizes contaminated items making them safe for processing personnel to handle. This terminal sterilization kills all microorganisms and renders the items safest for handling by processing personnel; however, these items have not been through the proper sterilization process and should not be used for sterile procedures.

Washer-decontaminators

Washer-decontaminators generally clean better than washer-sterilizers because they use a forceful jet or spray, but they *do not* terminally sterilize the contents. The washer-decontaminator generally relies on a germicidal detergent to decontaminate its contents. The cycle usually has a cold water pre-rinse phase, then a detergent-wash phase, a clear-water rinse phase, and a dry phase. The washer-decontaminator may be used on more items than the washer-sterilizer because it *does not* operate at extreme temperatures. However, the items must still be able to withstand moisture and immersion. Like the washer-sterilizer, the washer-decontaminator relies on removal of gross contaminants before the cycle; it finishes what the scrub technician started. Also like the washer-sterilizer, the washer-decontaminator renders the item biologically safe for handling by processing personnel.

Ultrasonic cleaners

Ultrasonic cleaning uses high-frequency sound waves to clean surgical instruments. This method is ideal for cleaning the hard-to-reach areas and surfaces such as the instrument box locks, ratchets, and jaw serrations. *Ultrasonic cleaning does not sterilize or decontaminate.* It is a follow-on process to remove fine particles and debris from inaccessible areas. All items must be initially cleaned and decontaminated *before* ultrasonic cleaning. It is important that you *do not operate the ultrasonic cleaner with the lid open*. The cleaning action causes aerosolization which can potentially disperse microbes into the work environment.

The actual process by which the sound waves remove soil is called *cavitation.* High-frequency sound waves (created by the cleaner's sonic generator) cause tiny bubbles to form in the detergent-water bath. The bubbles expand until they become unstable, then they implode (collapse) causing a temporary vacuum where the bubble existed. The rapid implosion of these microscopic bubbles dislodges, disperses, and dissolves soil. Because the bubbles are small, they easily slip into crevices and irregular surfaces. The cavitation, along with the heat, detergent, and water in the ultrasonic cleaning bath, combines to provide an extremely effective method of removing tenacious organic soil and debris.

Change the water in the ultrasonic cleaner at least daily, and whenever it becomes discolored or visibly soiled. When you drain the tank at the end of the duty day, use an approved tuberculocidal germicide to disinfect the tank and all surfaces of the machine.

In addition to the three primary mechanical cleaning machines (washer-sterilizers, washer-decontaminators, and ultrasonic cleaners), you will likely need to use additional means to clean reusable items both large and small.

Washer-sanitizer

The washer-sanitizer is very similar to the washer-sterilizer. In the washer-sanitizer, the dirty items are exposed to several washes and rinses. Once this series of washes and rinses is complete, the load is exposed to live steam at atmospheric pressure. Steam, at atmospheric pressure, does not reach the same temperature it would in a sterilizer. The sanitation process reduces the number of microorganisms to safe levels as judged by public health care requirements. This process *does not* kill

spores, and may not destroy highly resistant microorganisms. The end result of using the washer-sanitizer is achieving medium-level disinfection only.

Cart washers

A cart washer is designed to clean carts. Automatic cart washers are equipped with wash, rinse, and steam cycles. You will also find some with drying cycles. Since the carts are cleaned with hot water and steam, it is important to remember the carts are very hot and must be allowed to cool before they are handled. Carts should always be inspected and spot-dried before placing supplies in them.

Depending on the design of the equipment, a variety of cleaning and disinfecting procedures can be performed. Some machines may operate at very low temperatures and be filled with disinfectant. In this case, the carts would be *disinfected* rather than sanitized.

You should wear insulated gloves, boots, aprons, and ear protection when operating this piece of equipment. You should also take precautions to avoid slips and falls.

Power washer and steam gun

The power washer and steam gun are other methods used to clean carts and some large equipment items. Both these devices should be used in a confined area with a drain in the floor. The area should be well ventilated. The floor, floor drain, and walls must be cleaned frequently so that particles splashed off items washed do not accumulate. When you clean the cart, you must open it and tilt it so the water will drain out. Then you can spray *and sanitize* the inside of the cart.

You should wear insulated gloves, boots, aprons, and ear protection when operating this piece of equipment. You should also take precautions to avoid slips and falls.

Arranging items for mechanical cleaning

Ideally, the scrub technician properly arranges instruments and other reusable items in the containers after initial cleaning in the operating room before transport to the decontamination area. If the items are properly arranged, the decontamination staff member can simply open the container, immerse the items in the presoak/pre-rinse solution for the specified time, then load the entire pan or basket into the mechanical cleaning device. This method provides the best measure of protection for all staff members because the number of staff members actually handling the biologically contaminated items is minimal.

Guidelines for properly arranging items to provide *optimal mechanical cleaning* are:

- Items should be placed in perforated containers such as pans, trays, or baskets.
- Heavy instruments should be in separate trays from lighter ones, or, heavy items should be placed in the bottom of the container, lighter ones on top.
- Sharp or pointed items should be placed in separate containers, or should be placed on top of all other items. They should be arranged so the sharp or pointed areas will not be damaged by contact with other instruments, and so they will not injure processing area personnel.
- Concave surfaces of items should be placed face down, or to the side, to allow the solution to flow through, rather than pool on, the surface.
- Open all hinged instruments and disengage ratchets; ringed instruments may be placed on a “stringer” to help hold them open.
- Disassemble multi-part instruments as much as possible. Ensure small pieces are safely contained so they will not be lost.
- Arrange all items neatly; they should not be simply piled in the container. Do not overload the instrument trays.

Use the following guidelines for *ultrasonic cleaning*:

- Ensure items will be fully immersed in the cleaning bath. Ideally, instruments are covered by at least one inch of solution.
- *Do not mix* instruments made of dissimilar metals in the same load. Dissimilar metals may electro-chemically react and cause pitting or otherwise hasten corrosion.
- Avoid putting plated instruments in the ultrasonic cleaner. The high-frequency vibrations in the cleaner may cause the finish to flake or chip.

Always follow the manufacturer's instructions when operating any mechanical cleaning equipment, and ensure you are familiar with emergency or safety procedures. *Never operate a cleaner or any other medical equipment unless you are adequately trained and are familiar with all operating controls and processes!*

Lubricating instruments

The final step in cleaning and decontaminating instruments is lubricating them. As long as the manufacturer allows it, all instruments with moving parts should be lubricated after cleaning and decontamination. The cleaning and decontamination process removes any lubrication from the instruments, and non-lubricated instruments "wear-out" faster than lubricated ones.

Most metal surgical instruments are lubricated by immersing them in a water-soluble lubricating solution commonly called *instrument milk*. Water-soluble milk is used because steam can penetrate it and sterilize the instruments. The milk is mixed, according to manufacturer's directions, in a container or tank large enough to allow a full tray or pan of instruments to be fully immersed in the solution. If the container has a lid, most instrument milk manufacturers allow the mixed solution to be reused for one to two weeks. Many washer-decontaminators on the market today already have a built in cycle that will complete the instrument milking for you. An audible alarm will let you know when it is time to replace the empty container.

The lubricant is applied by immersing the instruments in the solution for at least 30 seconds. The instruments are then removed from the solution and the excess solution is allowed to drain. The lubricant leaves a very thin film on the instruments, even in tight areas such as box locks, hinges, and pivot points. *Do not* rinse or wipe off the lubricant, any excess will evaporate during a steam sterilization cycle.

Specialty instruments should be lubricated only according to manufacturer's recommendations. Special techniques and guidelines apply to air-powered equipment and some endoscopic instruments. Mineral oil, silicone-based, and petroleum-based lubricants are *not used* to lubricate surgical instruments—except for the internal motors of some powered equipment—because they interfere with steam, ethylene oxide, and chemical sterilization techniques.

Summary

This lesson covered the initial steps of the reprocessing of reusable items—cleaning and decontamination. It began with an overview of the terms used in the cleaning and disinfection process, then moved to a detailed discussion of these methods. You should have learned that the critical initial cleaning begins with the scrub technician in the operating room. Instruments and other items are then cleaned and decontaminated manually or mechanically. Mechanical processing is the more desirable method. The lesson finished with the final step of the cleaning and decontamination process: lubrication of the instruments.

You can see from your study of this lesson that there is a lot more to instrument cleaning and care than initially meets the eye. To ensure your surgeons always have clean, fully functional instruments to operate with, you and your co-workers must learn and follow basic guidelines for the care, cleaning, and maintenance of all surgical instruments. As stated throughout this course, always read

and follow local policies and manufacturer's instructions for preparing and using all cleaning and chemical disinfectant compounds, as well as those for operating, cleaning, and sterilizing equipment.

210. Sorting and inspecting surgical instruments

After all foreign materials have been removed from the surfaces of surgical care items through appropriate cleaning and decontamination processes, and the instruments are lubricated, they are ready for the follow-on steps of the processing cycle—sorting, inspecting, assembling, and final sterilization. In this lesson, we discuss how to sort and inspect instruments.

Before instruments are stored or sterilized for use, they need to be sorted and thoroughly inspected for cleanliness, defects, and proper function. Normally, it is too late to perform a thorough inspection of instruments just before they are used, and the bioburden makes it impractical to do so before they are cleaned and decontaminated. So, the best time to do a critical inspection is *after* the instruments are cleaned and decontaminated, but *before they are stored or packaged for sterilization*.

Sorting

The most common technique used for sorting instruments is to separate them into different stacks or groups on a large table. As you go through the instrument cleaning pan, try to pull out like instruments that can then be separated into functional groups on your assembly table. During this process, be vigilant of any sharps that could have inadvertently been left inside of the instrument pan. If a sharp (i.e., needle or blade) is found, immediate notify the SPD NCOIC and follow local policies. For example, most sets contain several kinds of hemostats including mosquito clamps, criles, and Kelly clamps. As you go through the pan, try to locate and pull out all hemostats and separate them into groups. Put all mosquito clamps together, all criles together, and all Kelly clamps together. This sorting process can be done with all types of instruments such as retractors, scissors, thumb forceps (pickups), scalpel handles, osteotomes, bone-cutting forceps, etc.

A good way to keep all ring-handled instruments together is to put them side-by-side on a rolled towel. This prevents the instruments from getting tangled together and makes them much easier to identify and count when placing them into sets. Be sure to open the ratchets of all ringed instruments (if they have ratchets) when sorting and grouping them together on your instrument roll. This facilitates inspection, instrument set assembly, and ensures that sterilizing agents contact all instrument surfaces.

Handle all sharp or delicate instruments carefully and by their handles to prevent personnel injuries and damage to the instruments. Assemble sharp cutting instruments in functional groups and place them on a towel to prevent them from being dulled or damaged by contact with the hard table surface.

Check instruments with multiple parts, such as the Balfour self-retaining abdominal retractor, to make sure all their parts are accounted for. It's very easy to lose or misplace a small part; therefore, it is very important that you learn and account for all the parts of the instruments you use and reprocess so you know immediately when a part is missing.

Sort reusable suture needles (free needles) and specialty needles according to size and type (specialty needles can also be sorted by gauge size). Make sure all parts of the different specialty needles are present. For example, certain tissue biopsy needles have a stylus that is inserted into the needle *cannula* (channel). The stylus must accompany the needle when it is stored or packaged for sterilization. The same sorting procedure applies to glass syringes and other special use items.

Many operating rooms and sterile processing areas have photographic identification books to help you identify, sort, and assemble various instruments, instrument sets, and special use items. If your OR does not have a locally developed book, refer to instrument catalogs or brochures to help you identify new instruments and the components of multi-part instruments.

Once you learn all the instruments used in your surgery suite, the sorting process becomes much easier. Always attempt to handle each instrument as little and as safely as possible. By thinking ahead

and organizing your sorting and assembly area, you not only save time and effort, you are also able to keep up with the flow of instruments, especially on busy surgery days.

After you sort the instruments into functional groups, you need to thoroughly inspect them.

Instrument inspection

Why bother inspecting instruments? After all, it takes a lot of time and causes "logjams" of instruments in the processing room. The two primary reasons for routinely inspecting surgical instruments and other patient care items are to prevent patient injury and to avoid delays during surgical procedures. Instrument inspection can also prevent your surgeons from getting frustrated or upset when an unwary scrub tech hands them a defective instrument. Routine instrument inspections allow for early identification, repair, or replacement of damaged, worn, or defective instruments.

When to inspect instruments

Instruments that have been in service should be routinely inspected after they are cleaned and decontaminated, and before they are sterilized or stored. This inspection should be a thorough one, where every part of each instrument is closely checked for cleanliness, function, and damage. Instruments should also be checked by the scrub technician while preparing the sterile field before surgery. The scrub should also get in the habit of double checking instruments before passing them to the surgeon, as well as during the breakdown of the setup at the end of the operation.

New instruments should be cleaned and thoroughly inspected for defects and proper function *before* they are first used. This is important because the Air Force buys instruments from several different suppliers, and, as a result, the quality and design varies. Some instruments may be poor in quality, design, or workmanship. Defective or low-quality instruments need to be identified and rejected. If a large number of instruments from one supplier are bad, then they are returned to medical logistics for credit and a formal material complaint is filed. We discuss this more in depth in CDC 4N151B. Instrument inspection is an essential quality assurance program that surgical personnel routinely use to help prevent harm to the patient, expedite surgery, and increase the overall quality of care.

Inspection techniques

We already mentioned that you should inspect all instruments for cleanliness, but how do you check for proper function or signs of damage? Figure 3–1 shows the typical parts of an instrument. You should already be familiar with these parts; the figure is included to ensure you are not confused by terminology as the inspection techniques are covered. The following table contains some of the more critical things you should check for when inspecting your instruments.

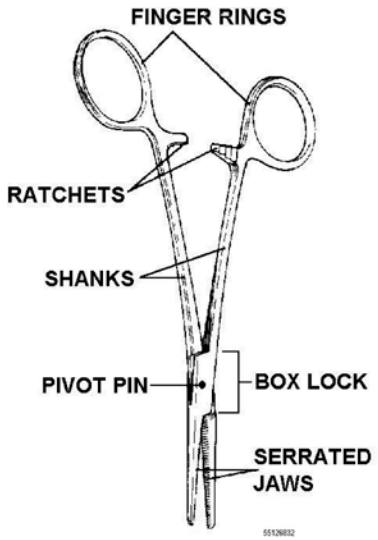

Figure 3–1. Parts of a surgical instrument.

Critical Inspection Areas for Instruments

Check the hinges and box locks for cracks (fig. 3–2) and loose pivot pins or screws.

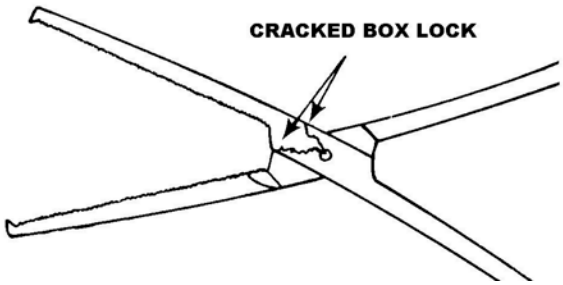

Figure 3–2. A cracked box lock.

Check all jaws for proper alignment (fig. 3–3). This includes checking to see if the ends of the jaw are equal length and thickness, that serrations mesh together properly, and that the tips come together without overlapping.

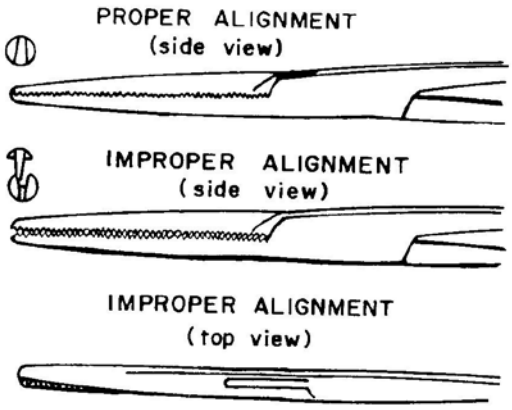

Figure 3–3. Instrument jaw alignment.

Check the ratchet closing mechanism for signs of wear and proper function. The ratchets should lock smoothly (with an audible “click”), open easily, and hold firmly, without springing open. To test the ratchet mechanism, close the forceps to the first ratchet tooth, then, as shown in figure 3–4, tap the ratchet area of the instrument lightly against the table edge or other solid object. If the ratchet pops open, the instrument is considered *sprung*; remove it from service.

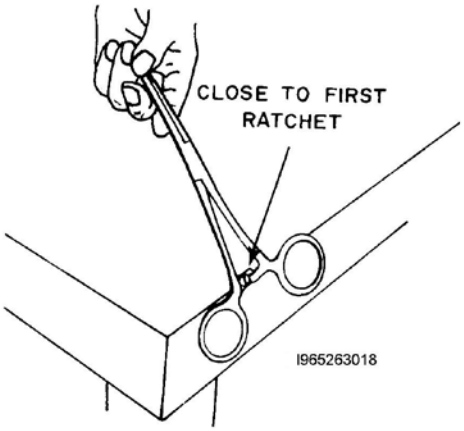

Figure 3–4. Checking the ratchet mechanism.

Check for bent shanks by visually checking the alignment of the shanks. Does the ratchet mechanism line up properly? The ratchet teeth should naturally come together, you should not have to bend the instrument shanks to get them to meet. To test the shanks of hemostats and similar grasping instruments for adequate tension, hold the instrument perpendicular to the table top, grasping it by the bottom finger ring. The instrument jaw should be closed, and there should be a slight gap between the two prongs of the ratchet mechanism. If the ratchets are touching, the jaw tension will not be adequate; if there is a large gap, the jaw tension may be too great.

Critical Inspection Areas for Instruments

Check for proper jaw tension and grip.

- Watch the tips of the jaw as you close the instrument; the tips should meet before the rest of the jaw closes.
- Next, close the instrument to the last ratchet tooth and hold the instrument up to a light. If you can see a gap at the tips of the jaw, the jaws are damaged.

A final jaw test is the *foil test*.

- Simply place a piece of thin aluminum foil between the jaws of the instrument and close the jaws.
- The crush-pattern left on the foil should be uniform from the tip to the base of the jaw.

This technique is particularly useful for checking the jaw closure of delicate needle holders. Figure 3–5 shows the difference between improper and proper jaw closure crush patterns (the pattern illustrated is that of a cross-serrated needle holder).

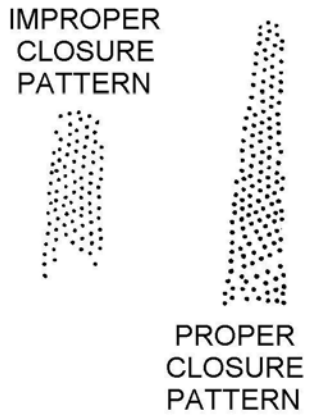

Figure 3–5. Foil test crush patterns.

Check needle holder jaws not only for proper tension, but also for worn serrations and their ability to firmly hold needles. Examine the needle gripping surfaces. If they are badly worn, try clamping a needle in the jaws. If the needle can be wiggled when the ratchet is closed to the second tooth, the instrument is defective.

Check scissors for bent or broken tips, burrs or nicks on the cutting surfaces, loose or damaged pivot screws or pins, and sharpness (fig. 3–6). Test scissor sharpness by cutting a cotton ball. A sharp pair of scissors cuts cleanly through the cotton, all the way to the tips, without pinching the material between the blades.

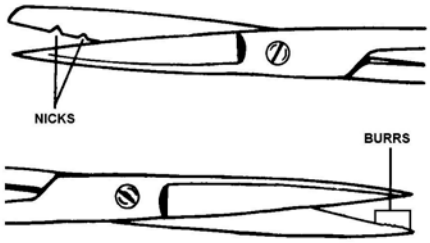

Figure 3–6. Defective scissors.

Inspect the cutting surfaces of all orthopedic osteotomes, rongeurs, bone cutters, gouges, etc., for nicks, burrs and sharpness (fig. 3–7). Check the jaw alignment and pivot points on all rongeurs and bone cutters.

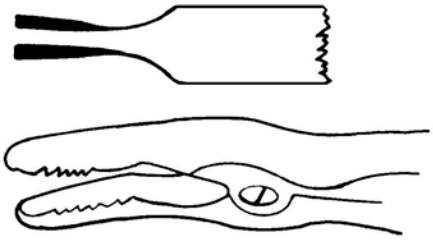

Figure 3–7. Damaged orthopedic instruments.

Causes and solutions for spots, stains, and corrosion problems

Many of the problems associated with deterioration of surgical instruments are linked to shortcuts in routine care and maintenance; others are linked to environmental conditions. For example, the “rust”

that appears on stainless steel instruments may actually be staining from chemical disinfectants. Stainless steel instruments can also appear rusted when they become stained by trace metals such as copper from the linings of sterilizers. Sometimes what may appear to be rust or corrosion can actually be baked-on blood and organic material. Water with a high mineral content also causes corrosion-like staining of instruments.

One easy way to test for corrosion on an instrument is to try to erase it with a pencil eraser. If the "rust" comes off, then the residue is a stain, not corrosion. To help you investigate and correct instrument corrosion, staining, pitting, etc., we briefly outline some of the common instrument care problems, their possible causes, and solutions.

Spotting

Dark and light-colored spots on instruments are usually traced to high mineral content—usually in the cleaning water and/or the steam used to sterilize the instruments. Spotting also occurs when moisture condenses on the instruments and evaporates slowly. This may occur if the sterilized instruments are removed from the sterilizer too soon, allowing cold air to condense the moisture inside the sterilized packs and sets. A faulty sterilizer drying cycle also leaves excessive moisture inside wrapped, sterilized items. Spotting can also be caused by using too much or improper types of detergent during cleaning.

Possible solutions to instrument spotting include using demineralized (soft) water for cleaning and rinsing instruments, "cracking" doors on sterilizers after the sterilizing cycle to allow a gradual cooling of sterilized items (this minimizes condensation), and reducing the amount of detergent used during instrument cleaning.

Staining

Discoloration and stains appear on instruments for a variety of reasons.

Discoloration and Stains		
Type	**Cause**	**Remedy**
Black or purple-colored stains	• Cleaning instruments with ammonia-based detergents. • Exposure to steam contaminated by the chemicals facility maintenance personnel use to clean the lime deposits from the steam lines.	• Avoid use of ammonia-based cleaners. • If traced to steam line cleaners, install steam line filters and ensure soft water is used for steam production.
Gray-blue stains	Repeated exposure to chemical disinfectant solutions.	• Always follow the manufacturer's recommendations for mixing and changing the solution. • Avoid prolonged soaking of instruments. • Use soft or distilled water when preparing the solution (if applicable).
Brown stains or discoloration on stainless steel instruments (A chromic oxide film that forms on instrument surfaces when they are exposed to the heat of steam sterilization processes)	• Using some types of instrument cleaning compounds on the copper parts of the autoclave. • The chemicals in the detergent actually dissolve copper; the copper becomes suspended in the detergent solution, and then gets deposited on the instruments through an electrochemical reaction (similar to electroplating).	• Always use manufacturer recommended cleaning agents. • Use only detergents made specially for instrument cleaning on instruments, and detergents for sterilizer chamber cleaning on sterilizers.

Corrosion

Corrosion of instruments can be caused by one (or more) of the following:

- Dried blood or organic material left on the instruments (particularly in hard-to-clean areas).
- Excessive moisture left on instruments due to condensation following steam sterilization.
- Transfer of deposits and scale from improperly cleaned sterilizer chambers or racks to the instrument surfaces.

To minimize corrosion, thoroughly clean instruments to ensure all organic material is removed. Ultrasonic cleaning after gross soil removal and decontamination is highly recommended for cleaning inaccessible areas of most instruments. Condensation is reduced by ensuring sterilizers are functioning properly (especially drying cycles) and by cracking autoclave doors in the manner previously described. To prevent corrosion caused by sterilizer scale and deposits, routinely clean the chamber and racks of the sterilizer according to manufacturer recommendations.

Pitting

The most common cause of instrument pitting is prolonged soaking of instruments in saline. Prolonged exposure to blood or corrosive chemical disinfectants and the use of excessively alkaline (high pH) or acidic (low pH) detergents for instrument cleaning also causes pitting. Yet another cause of instrument pitting is mixing dissimilar metals during ultrasonic cleaning and steam sterilization processes.

You can sharply reduce the occurrence of pitting by taking the precautions listed below.

- Thoroughly rinse all instruments with clean water after exposure to saline.
- Make sure all instruments exposed to chemical disinfectants are also thoroughly rinsed with water.
- Avoid using high or low pH detergents. Use specially formulated instrument cleaning compounds with a neutral or only slightly alkaline pH.
- Never mix instruments made of different metals in the same ultrasonic or steam sterilizer load. For example, do not put stainless steel instruments in the same tray or basket with chrome-plated or brass instruments.

Rusting

The two most common causes of rust formation on surgical instruments are rinsing instruments with mineral-containing tap water and mixing instruments made from different metals in ultrasonic cleaning or steam sterilization loads. Remedies for rusting problems are the same ones we've outlined before—do not mix metals in the ultrasonic cleaner and steam sterilizer and use distilled or soft water for final rinsing of all instruments.

Other guidelines for handling and inspecting instruments

To avoid a great deal of surgeon anger and frustration and prevent harm to the patient, follow the rules listed below whenever you're handling any type of instruments.

- Only use instruments for the purpose they were designed for. For example, do *not* use an osteotome for a screwdriver; do *not* use surgical tissue scissors to cut gauze, tubing, sutures, etc.; do *not* use a needle holder as a wrench or pliers; and do *not* use hemostats for tube clamps.
- Inspect every instrument for proper function *after each procedure* and *before it is used again.*
- Always remove dull or damaged instruments from service. Allow OR supervisory personnel to inspect them and determine if the instruments are to be repaired or replaced.

- If instruments must be marked for identification, use an electro-etching device or other method that will not harm the finish of the instrument surface. *Impact stamps or vibrating engravers are not recommended.*

Disposition of defective instruments

When your inspection turns up a damaged or defective instrument, what do you do with it? First, you should remove the instrument from service and replace it with a serviceable item, if possible. Then, give or show the damaged instrument to your supervisor or an individual authorized to replace or repair instruments. He or she will decide if the instrument is to be sent to the manufacturer for repair or discarded for salvage. Most processing or assembly areas have separate containers to hold instruments designated for salvage or repair. When the salvage container is full, or at specified time intervals, the supply representative can turn in these items to medical logistics for salvage. Any instruments that need repair or sharpening are sent to an instrument manufacturer and repaired in accordance with contract arrangements made through medical logistics and the base contracting office.

Storage of unwrapped clean instruments

Many instruments are kept sterile in various kinds of sets or individually in peel-packs. However, there are many instruments in your operating room that are not placed in sets and sterilized. These include replacement instruments, specialty instruments that are not often used, and delicate instruments that must receive special care. These unsterile instruments are stored in cabinets or drawers.

Unsterile instruments should be stored neatly so they are easy to locate when needed. They should be stored so that they are protected from damage and functionally ready. This is necessary so they can be located, assembled, and sterilized in a moment's notice. Some of the recommendations for unsterile instrument storage are:

- Store instruments in closed cabinets or drawers according to the type of surgery for which they are primarily used. That is, all general surgery instruments are stored together, all orthopedic instruments together, and so on.
- Store instruments according to their type and use. In the general surgery cabinet, for instance, store all scissors together, and store each type and size together. All curved Mayo scissors should be in one group, all straight Mayo scissors in another, etc.
- Ensure all instruments are thoroughly dry before storage.
- Close instruments with ratchet mechanisms to the first ratchet tooth, not the last, to prevent tension and strain on the lock and tips.
- Store scissors completely closed to prevent damage to cutting surfaces.
- Place curettes, osteotomes, gouges, and other instruments with sharp, pointed, or delicate edges in wrappers or on a padded surface to protect their edges.
- Thoroughly clean the instrument room and cabinets at least once a week. The instruments stored in the cabinets should also be cleaned periodically to eliminate dust buildup on their surfaces.

Instruments and supplies that are not put into unsterile storage are sorted and arranged into packs and sets. The selection and arrangement of these items is covered next.

211. How to select and arrange surgical items for packaging

Once instruments and supplies used for surgical patient care have been sorted and inspected, they are ready for the next processing step. As mentioned in the previous section, some of these items are placed in unsterile storage areas. The remaining items are either packaged individually or arranged into packs and sets that will be sterilized.

Selection of items for surgical packs and sets

How can you determine what items need to go into a particular set or pack? One common method is using pre-printed "count sheets" to assemble each set. These sheets are prepared for each type of set in your facility and used as a "map" for instrument set assembly. They tell you exactly how many, what size, and what type of instrument to place in the set. They are often divided into specific sections (e.g., bottom of tray, on stringer, rolled towel #1, rolled towel #2, etc.) and may also list exactly where to place each instrument in the set.

Using the count sheet method, you can mark any discrepancies, such as missing instruments, on the count sheet. The sheet is then signed by the assembler and placed on the outside of the instrument set. This method allows the end user (customer) to see exactly what is in the instrument set and what is missing from it before the set is actually used.
Another method used to assemble instrument sets is often called the "cardex system." This system uses a series of 5- by 8-inch index cards that provide you with all essential information you need to assemble, wrap, and sterilize different packs and sets. Information typically provided includes:

- The name of the set or pack.
- What the set or pack will be used for.
- A detailed listing of all the contents, broken down into different logical groupings (e.g., scissors, retractors, ring handled instruments, linens, etc.).
- How the set or pack is packaged.
- The method of sterilization to use.
- The location where the set or pack is stored.
- The number of packs or sets needed to sustain normal operations (commonly called the level).
- How the contents are supposed to be cleaned.

Some file-card systems include drawings or photographs of the contents and final arrangement of items within each set or pack.

The system used in your facility is usually determined by both the OR and SPD supervisors with input from senior NCOs. Regardless of the method used, it should identify specific quantities and types of all items contained in each set. This standardized inventory is necessary to facilitate instrument counts and to ensure adequate numbers of specific items are put in the set to meet the needs of a typical procedure the set is designed for.

Once you retrieve the count sheet or instrument set card, you can begin arranging the instruments into a set or pack.

Arranging items in sets and packs

Proper arrangement of items in a pack or set ensures effective sterilization of all contents. It also allows for quick, easy removal of set contents in a logical sequence and facilitates instrument counting. Some items require special preparation when they are assembled for sterilization; local policy identifies these items and provides guidelines for doing so. The "routine" sets are generally assembled as described in the next few paragraphs.

Instrument assembly and arrangement

As a minimum, the bottoms of all pans used for instrument sets must be either open mesh, or perforated to ensure steam circulates freely and contacts all instruments. The pan is often lined with a towel to protect the instruments from damage, though this is optional and determined by local policy.

The general rules of instrument set assembly are:

- Place large or heavy instruments, such as retractors, in the bottom of the pan.
- Place delicate instruments and scissors on top, usually protected in a rolled towel.
- Put all hinged instruments into the set with the *ratchets and jaws open* to allow steam contact with all surfaces.
- Arrange ring-handled instruments on stringers, by size and type, generally with short instruments on one end and longer instruments on the other. All curved jaws should face the same direction. The stringer used should keep the ratchets from engaging and hold the jaws open. Small quantities of ringed instruments may be strung using sponge forceps, towel clips, or special racks.
- Disassemble multi-part instruments to allow steam contact with all parts.

Arrange all instruments in the pan in a neat, orderly fashion and in a standardized sequence, usually in the order listed on the count sheet or assembly card. This facilitates setting up the sterile field and performing instrument counts.

Metal basins and cups

When two or more basins or cups are placed together, separate them by a layer of linen or gauze to allow for steam contact with all surfaces. When placed in sets, ensure they are placed so they will be on their sides and will not collect moisture during the sterilization cycle. Basins and cups should be individually packaged in wrappers or peel-packs.

Glassware

Wrap glass items such as medicine glasses, blood tubes, and glass syringes, before placing them in a set to “pad” them and help prevent breakage. Wrapping them also confines the glass fragments in the event an item does break. Disassemble items that have multiple parts, such as glass syringes, and wrap each part separately.

Items with lumens

Flush any items with hollow channels or lumens, such as tubing, hypodermic needles, catheters, and drains with distilled water. Theoretically, this is necessary to eliminate cool air pockets inside the lumens during the sterilization process. Cool air pockets prevent destruction of microorganisms. The residual water left in the lumen vaporizes when heated to sterilization temperatures, creating its own steam, which sterilizes the lumen.

Linens and gauze

All linen items included in a pack or set are freshly laundered to ensure the fibers contain sufficient moisture to prevent fabric deterioration and possible superheating during steam sterilization. Linen items are generally fan-folded to allow adequate steam circulation between each fabric layer. Fanfolding also facilitates handling and use during surgery. If multiple layers of linen or gauze sponges are placed in a pack, crisscross the different layers at right angles to aid in steam penetration. Remember, if X-ray detectable sponges are placed in a pack, they are packaged in groups of 5 or 10 so they can be counted on the sterile field. Your local policies and procedures dictate exactly what to do when including sponges in sets and packs.

Chemical indicators must be placed inside each set, pack, or individually wrapped item. These indicators change color when exposed to the conditions associated with different sterilization processes. *They do not indicate sterility, only that the pack, set, or item has gone through a sterilization process*. The indicators provide an additional check against improper packaging, loading, or operation of sterilizers.

Place the chemical indicator as close to the geometric center of the pack as possible. When a count sheet is sterilized inside the instrument set, the chemical indicator may be stapled to it. All scrub and

circulating personnel immediately look for these indicators after opening a sterilized item to see if the color has changed. *If the indicator has not changed color, or the color change is variable, consider the item unsterile and do not use it on a patient.* We discuss chemical and biological sterilization monitors in-depth in a later unit.

Size and weight of packs and sets

At one time, the maximum size of a pack or set was 12 by 12 by 20 inches, and the maximum weight was 12 pounds. Numerous studies have shown, and current standards state, that the size and weight are not the critical factors; there is no "magic number" for limiting sets.

The size and weight of sets should be determined primarily by the ability of hospital personnel to move, lift, and carry the set using proper body mechanics, and by the density of the set. If staff members complain about the size and weight of a set, or if they state they cannot carry it, the set is probably too large. If a retractor is 24 inches by 20 inches, the pack is obviously going to be large; you will probably package it separately, not as part of an instrument set. If an instrument contains numerous pieces that all fit together to form a dense mass, it is also usually packaged by itself, not as a part of a set.

The goal of configuring the package is to distribute the mass; thereby distributing the density of the contents. If one particular instrument set is recurrently found to be wet when opened, the density is probably too great for effective sterilization and drying. Redesign the set to distribute the mass, or divide the set into separate components that can be sterilized more effectively.

Summary

After studying the material in this section, you should have a greater understanding of how to clean, decontaminate, sort, inspect, and assemble surgical instruments. The first lesson began by looking at how to clean and decontaminate surgical instruments. The next lesson explained the why, what, when, and how of instrument sorting and inspection. The section ended with some general guidelines for instrument set selection and arrangement. Answer the following questions, and review any areas you do not understand, before beginning the next lesson.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

209. The process of cleaning and decontamination

1. In the context of instrument and supply processing, define the following:
   a. Cleaning.

   b. Decontamination.

   c. Disinfection.

   d. Terminal sterilization.

2. Where and when does the cleaning process begin?

3. Who should remove gross contaminants from all instruments and supplies? List some ways this is done.

4. How should sharp instruments and all instruments that may puncture, lacerate, or otherwise injure somebody be placed in a container for transport to the decontamination area?

5. What is the purpose of pre-soaking or pre-rinsing?

6. When should you use the manual cleaning method?

7. List the PPE required by OSHA and the CDC for manual cleaning.

8. Why should you keep items immersed and avoid splashing as you manually clean them?

9. Briefly describe the general procedure for cleaning air-powered instruments.

10. What types of instruments are processed through a washer-sterilizer?

11. Briefly describe the difference between a washer-sterilizer and a washer-decontaminator.

12. What term describes removing soil from instruments by the use of high-frequency sound waves generated by an ultrasonic cleaner?

13. List some of the guidelines for arranging items for mechanical cleaning.

14. What is instrument milk?

15. What types of lubricants are not used on surgical instruments? Why?

210. Sorting and inspecting surgical instruments

1. How do you organize and keep ring-handled instruments together during the sorting process?

2. List some ways you protect delicate or sharp instruments from being damaged during instrument sorting.

3. How do you sort reusable suture needles and specialty needles?

4. Where may you find pictures and information that help you identify, sort, and assemble instruments?

5. What are the two primary reasons for routinely inspecting all instruments?

6. When are all instruments inspected thoroughly?

7. Why is it important to inspect new instruments?

8. Identify six things you check during a routine instrument inspection.

9. What simple test can you perform to test for instrument corrosion?

10. List three causes of spotting on surgical instruments.

11. What commonly causes the following instrument problems?
    a. Black or purple stains.

    b. Corrosion.

c. Pitting.

d. Rusting.

12. What is the first thing you do with a damaged instrument?

13. How do you store clean, unsterile instruments that have ratchet mechanisms? Why is this storage method necessary?

211. How to select and arrange surgical items for packaging

1. List two methods commonly used to determine what items need to go into a set or pack.

2. What do you do with all hinged instruments that are placed in a set? Why is this action necessary?

3. Why is it necessary to put instruments in a pan in an orderly, standardized sequence?

4. What are the reasons for individually wrapping all glass items that are placed in an instrument set?

5. What should be done with all items that have hollow channels or lumens? Why?

6. Why are linen items placed in a pack usually fan-folded?

7. Where should chemical indicators be placed inside each pack, set, or individually wrapped item?

3–2. Packaging for Sterilization

After surgical instruments and supplies have been cleaned, decontaminated, sorted, and assembled for sterilization, they must be packaged in a manner that will preserve their sterility until they are needed for use. The three most common methods of packaging sterile items are wrapping them, putting them in paper-plastic peel-packs, and using rigid container systems. Each of these packaging methods

requires different techniques and handling methods. We begin our discussion with the purpose and characteristics of packaging materials for sterilization.

212. Packaging materials for sterilization

All sterilization packages are not the same. To select and use the proper materials for packaging the wide variety of patient care items, you have to know what characteristics a package should have, and what types of packaging materials are commonly used. You also need to be familiar with the methods we use to package items for sterilization.

Purpose of packaging

The primary purpose of packaging patient care items is to maintain their sterility up to the point of use. To effectively do this, the package must allow the item to be handled by non-sterile personnel without contaminating the sterile contents. The package must also maintain the sterility of the item during storage by providing an effective barrier to airborne microbes and other contaminants, such as dust insects, and other "pests." When wrappers are used for packaging, they offer the additional benefit of extending the sterile field to a greater area than just the insides of the package—provided they are opened using proper aseptic technique.

Desirable characteristics of packaging materials

Consider several factors when evaluating materials that will be used to package items for sterilization. The specifications or desirable characteristics for packaging materials are listed below.

Permeability during sterilization

The packaging material has to be permeable during the sterilization cycle. It must permit the sterilizing agent to penetrate the package and fully contact all surfaces of the items being sterilized and must also allow non-sterile air to escape from the package during the sterilization cycle. Package permeability must allow the sterilant to escape at the end of the cycle, and must not hinder drying of steam sterilized loads or aeration of ethylene oxide sterilized loads.

Impermeability after sterilization

The package has to act as a barrier after sterilization. It cannot allow dust or other contaminants to enter the package. Any material used in packaging has to be able to maintain the contents in a sterile condition during handling, sterilization, transportation, and storage.

Durability

The package should resist tearing and puncturing under normal use. It must remain intact to provide protection for the maximum permissible storage period.

Versatility

The package must be capable of containing and protecting items of various sizes, shapes, and natures. No one package is required to (or capable of) containing every type of item to be sterilized, but the package selected for a particular item must be versatile enough to hold and protect that particular item.

Ease of use

The package must be easy to open and allow removal of the sterile contents without contaminating them.

Protection

The wrapper must protect the contents of the package from damage. Some delicate items are more suitable for rigid containers with protective mats than they are for being wrapped without a container. The container reduces the likelihood of damage.

Conservation of space

Space conservation in loading the sterilizer and in using the sterile storage area is necessary. A shortage of space can dictate the use of disposable packaging materials such as wrappers and peel-packs that generally occupy less space than rigid containers.

Safety

The packaging *must not* contain toxic ingredients or non-fast dyes that may escape into the environment or leech into the items contained. The package must also be lint free or low linting to reduce dust and other airborne contaminants.

Total cost economy

Cost is influenced by factors as time and labor, procedure efficiency, and material price. Cost is one very important factor to consider when selecting a packaging material. A true picture of cost is only obtained by looking at the whole picture. You must consider:

- Original cost.
- Number of times the material can be reused.
- Efficiency of use.
- Labor involved.

Some other considerations are collecting, moving, storing, laundering and repair (if non-disposable), inspecting, and actually using the material being considered.

Packaging materials

Wrappers are the oldest, and still the most common, packaging materials. Two basic types are available: non-disposable and disposable.

Non-disposable wrappers

Non-disposable wrappers are generally *woven fabric* or cloth (textile). Many fabrics are available for use, but the traditional and most commonly used fabric is 140-thread count, unbleached cotton muslin. Muslin has good filtering characteristics, does not retard the passage of sterilants into the package, and is easy to work with. When muslin is used to wrap items, at least four layers (two double-thickness wrappers) of muslin is recommended to allow sterilant penetration and to reduce the incidence of tears and punctures. However, muslin is not an ideal wrapping material because of its many disadvantages. Muslin wrappers mildew, yellow with age, and wrinkle easily. Muslin is porous, so shelf life of muslin wrapped items is usually limited to a *maximum* of 30 days (unless covered in protective plastic). The fibers in the muslin are susceptible to humidity, and porous enough to permit infiltration of microorganisms between the fibers. One of muslin's major disadvantages is its tendency to wick moisture into packages. This can cause retrograde contamination (sometimes called "strike-through") when muslin-wrapped items are placed on wet surfaces.

In many hospitals using fabric wrappers, 140 thread count muslin has been replaced by 180 thread count, 50% cotton and 50% polyester woven materials. This material is slightly more moisture-resistant than muslin, but it still requires four-layers (two double thickness wrappers) to be considered an effective barrier. Another cloth fabric, 270- to 280-count combed pima cotton, is treated with a water-resistant finish. This fabric is moisture-resistant and a single (double-thickness) layer may be used, which means the item may be wrapped using only one wrapper.

One of the disadvantages of cloth wrappers, or for any sterilizer load with a high fabric content, is the risk of *superheating* during sterilization. Superheating occurs when linen (muslin) items have *not* been laundered before sterilization. Laundering replaces the moisture that is removed from the linen by the high heat of sterilization. Superheating occurs when previously sterilized, dehydrated fabrics are re-sterilized without being laundered during the interval. The dried fibers in the muslin rapidly absorb water from the steam. This reduces the steam saturation surrounding the load, but

supersaturates the non-laundered wrappers and linen. In turn, this will result in the release of latent heat as the absorbed water vaporizes, resulting in localized superheating. Superheating gradually destroys the fibers of these woven textiles.

Another disadvantage is that woven textiles lose strength and barrier capabilities after being subjected to numerous sterilization cycles. Eventually (after 50 to 75 launderings) their barrier properties completely break down. To combat this problem, some companies "bar-code" their linen wrappers and other items. A computer monitors how many times each bar-coded item is laundered, and the item is removed from service after a specified number of processings.

Disposable wrappers

Disposable wrappers generally fall into two classifications: paper-based wrappers, and non-woven fabric wrappers.

Paper-based wrappers

Paper wrappers offer a relatively inexpensive alternative to textile wrappers for many common processing applications. All paper-type packaging materials are considered disposable and should only be used once. Paper wrappers are, in many instances, more economical than woven textiles. But they are *not* very durable and can easily wick moisture if not treated with chemicals. Some paper wrappers are bonded with plastics or treated with chemicals to increase strength and moisture resistance. There are two other major disadvantages of using paper materials to wrap patient care items:

- The paper is more difficult to handle during wrapping. Some wrappers have an almost cardboard-like texture and are very hard to fold and hold in position.
- Most paper wrappers have "memory." This refers to the wrapper's tendency to return to its original shape. A paper wrapper tends to try to return to its unfolded state each time an attempt is made to hold or fold it during wrapping. They also tend to try to return to the folded state after sterilization; this can cause breaks in aseptic technique, particularly when inexperienced personnel, unfamiliar with handling paper wrappers, try to open a paper-wrapped sterile item.

To overcome the disadvantages of paper wrappers while preserving the advantages of disposable wrappers, non-woven fabric wrappers have been developed.

Non-woven fabric wrappers

Non-woven fabric wrappers are usually made of multiple types of material that are bonded together by stamping, pressing, rolling, or some other non-weaving method. They offer several advantages over woven and paper-based wrappers.

Advantages of Non-woven Fabric Wrappers	
Advantage	**Amplification**
Available in different weights, or thicknesses, for various applications	• Light weight non-woven fabric is used much as the other wrappers are; two wrapper layers are used to wrap each item. • Medium-weight non-woven fabric also requires two wrapper layers, but its extra strength makes them more effective barriers when used to establish sterile fields. • Heavy-weight non-woven fabric often consists of two wrapper layers bonded together; only one wrapper is required to package the item.
Nearly as flexible (memory-free) as cloth wrappers	• The flexibility, or drapability, of the wrappers makes them ideal for packaging items that are usually used to establish a sterile field. • When the wrappers are opened, they drape over the table or stand without the "memory" tendency of paper wrappers.
Nearly lint-free	Like most paper wrappers, non-woven fabric wrappers produce far less lint than their woven wrapper counterparts.

Disposable	• Disposable wrappers eliminate the need for inspection, laundering, and repairing of wrapper materials. • They are used once and thrown away, saving much reprocessing labor and time.
Excellent barriers to microbes and moisture after sterilization	Non-woven fabrics are generally more impermeable than paper or cloth. This increases their barrier characteristics during storage and use of the enclosed items.
Stronger and more tear resistant than paper	Non-woven fabrics can withstand greater handling stress than paper wrappers. They are less likely to tear when being loaded or unloaded on sterilizer carts and when being placed in or removed from storage.

The primary disadvantage of non-woven fabric wrappers is cost. They are the most expensive types of disposable wrappers to purchase, and because they are single-use, they are thrown away after the package is opened.

Peel-packs

Peel-packs are pouches or tubes made with a layer of paper on one side and plastic on the other. The paper ensures good steam penetration and the clear plastic allows the user to see what is in the wrapper. The pouches come in various sizes and are sealed on three sides with the fourth side left open. This creates a small, flat bag to insert the contents. After the desired item is inserted into the package, the open end is sealed, either with a fold-down adhesive flap or by using a heat sealer.

The tubes are similar to the pouches. The paper-plastic layers are the same, but they are sealed only on the sides. Peel-pack tubes come in long rolls and in various widths; they are cut to length and the ends are heat-sealed after the item is enclosed. If heat sealing is not available, some facilities allow the open ends of the peel-packs to be sealed by folding the end and sealing with tape; this method is *not recommended* because it is very difficult to aseptically open the package and remove the contents.

Rigid containers

A rigid container consists of a large plastic or metal pan with a lid that serves as an outer container, and a wire or mesh basket or pan that is used to hold the instruments or other items being sterilized. The outer container has a filter mechanism that allows the sterilant into the container during the sterilization cycle, but serves a barrier to keep microbes out after sterilization. The lid seals tightly and a locking device secures it to the container bottom; the locking device usually has provisions for a safety or security seal. Common safety devices include small plastic padlocks, tags, or plastic arrows that break if the container's locking device is opened. Many safety devices have built-in chemical indicators to show whether the container has been subjected to a sterilization cycle.

The filters on rigid containers vary in both design and placement. Some containers have filters in the bottom of the container and in the lid; these containers can be used in gravity displacement steam sterilizers, prevacuum steam sterilizers, and ethylene oxide sterilizers. Some containers do not have filters in the bottom; the filters are either in the top or in the sides. Containers *without perforated bottoms cannot be used* in gravity displacement steam sterilizers. Always be sure to follow the container manufacturer's and the sterilizer manufacturer's recommendations when using any rigid container system.

213. Packaging methods and labeling items for sterilization

To ensure that surgical patient care items remain sterile until they are used or their sterile shelf life expires, they must be properly packaged. From our previous discussion, you know there are numerous choices for packaging materials. However, even the best packaging material in the world is of little value if it is improperly used. Proper use includes placing the items in, sealing, and labeling the package.

Wrapping items for sterilization

The first method discussed is the oldest: wrapping sterile supplies. Before you actually wrap sterile supplies, you need to determine the proper size of the wrapper and conduct a final quality control inspection of the items beforehand.

Determining wrapper size

Choosing the proper size wrapper for the item you are going to wrap is very important. The size wrapper you use should allow for complete coverage around the item. It must also be large enough to create "dog-ear" flaps or cuffs which aid in opening the package. The depth of the flap fold should be approximately one-third the width of the pack. Proper cuff formation is essential so the wrappers can be opened by circulating personnel without contaminating the sterile inner contents. The item must be covered so each flap or cuff overlaps the previous one.

Most facilities across the Air Force Medical Service (AFMS) utilize two-ply wrappers produced by the manufacturer. However; if your facility uses individual wrappers, you will wrap each item twice; first with one wrapper, then identically with the other. Because local policies vary, *be sure that you know your facility's policy before you wrap any item for sterilization*.

If the wrappers of the item you are going to sterilize are usually used to form a sterile field, such as the wrappers for a double basin set, the wrappers used should be large enough to enclose the basins and, when opened, cover the double ring stand and extend well down the sides. This creates a sterile field with a safe margin of sterility. Never wrap items too loosely or too tightly; the wrapper should be snug enough to secure the pack contents, but not so tight that it tends to burst open during or after the sterilization cycle.

Pre-wrap quality inspection

Before you begin wrapping any item, perform a final quality check:

- Ensure an internal chemical sterilization indicator is included in the package.
- Look at how the items are arranged.
- Look for any missed stains or rust.
- Be alert for any other discrepancies.

If you make it a habit to check every item before wrapping it, you learn to quickly spot and correct any problems. Remember, you are the last person who will see this item before it is ready for use on a patient.

Diagonal wrapping method

The diagonal method of wrapping is normally used for small to medium sized items. The largest wrapper you'll most likely use to wrap an item using the diagonal method is 54 by 54 inches. Smaller wrappers, such as 36 by 36 inches, 24 by 24 inches, and 18 by 18 inches are used more frequently. When wrapping a patient care item using the diagonal method, follow the steps shown in figure 3–8 and described in the table that follows.

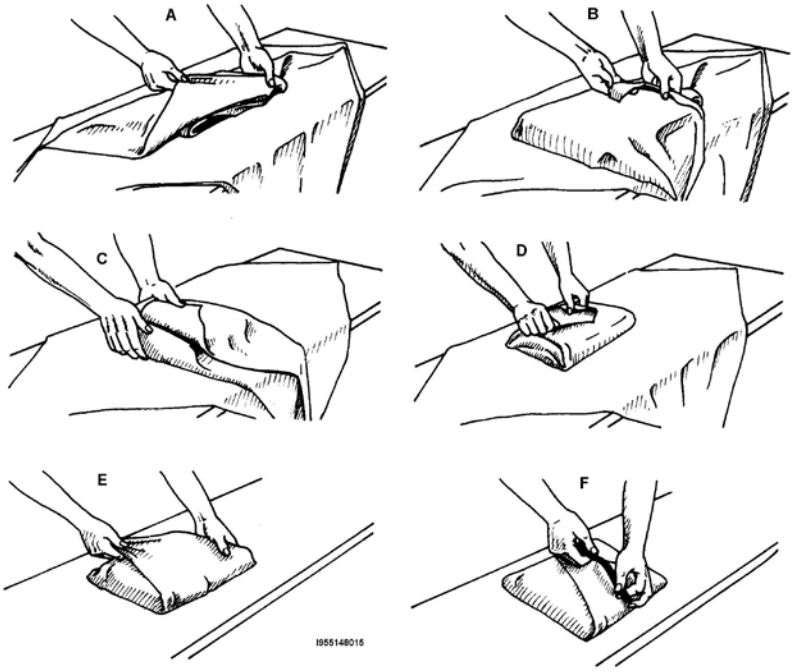

Figure 3–8. Diagonal wrapping method.

NOTE: Wrapping items in two-ply wrap is the most common method; however, if two separate wrappers are used, you must wrap the item one wrapper at a time (sequential wrapping).

Diagonal Wrapping Method	
Step	**Description**
1	Place square wrapper on the worktable with one corner toward you (two if you are using two single wrappers); it should look like a diamond. Place the item you are wrapping in the center of the wrapper(s), with the square side of the item parallel to your body. If you imagine lines drawn to opposite corners, they would divide a square item into four equal squares.
2	Fold the corner nearest to you (of the top wrapper) over the item. Fold the outer edge of the corner back towards you to make a tab or “dog ear” flap (fig. 3–8, step A).
3	Fold the right-hand corner of the top wrapper over the item being wrapped. Make a similar tab or flap. (fig. 3–8, step B).
4	Fold the left-hand corner of the top wrapper over the item being wrapped. Again, make a tab or flap (fig. 3–8, step C).
5	Fold the final corner of the top wrapper (furthest away from you) over the item being wrapped. Like the others, make a tab on this last fold (fig. 3–8, step D). The item now should appear completely wrapped; if you can see any portion of it, you either did something wrong, or you need a larger wrapper. Secure the wrapped package with the appropriate type of tape for the sterilizing method you are using (fig. 3–8, steps E and F).
6	If you are using two single wrappers, repeat steps 1 through 5 with the second wrapper (fig. 3–8, Steps A–D). Do not make a tab or flap on the last fold. Depending on local policy, you either “tuck” the wrapper into the “envelope” created by the wrappers, leaving a corner sticking out, or you wrap the flap around the item. Secure the wrapped package with the appropriate type of tape for the sterilizing method you are using (fig. 3–8, steps E and F).

Rectangular wrapping method

The rectangular wrapping method is seldom used for locally processed items. It is predominantly used to wrap drape packs when the wrapper is used as a back table cover. You will also use this method for linen packs in a contingency situation. However, some locally sterilized large basin sets, and a few extra-large instrument sets, must be wrapped using the rectangular method. Large rectangular wrappers (54 by 72 inches, or two muslin sheets folded in half lengthwise to form four layers of muslin are most common) are normally used to wrap these large packs and instrument sets. To wrap an item using the rectangular method, refer to figure 3–9 as you study the descriptions in the table which follows.

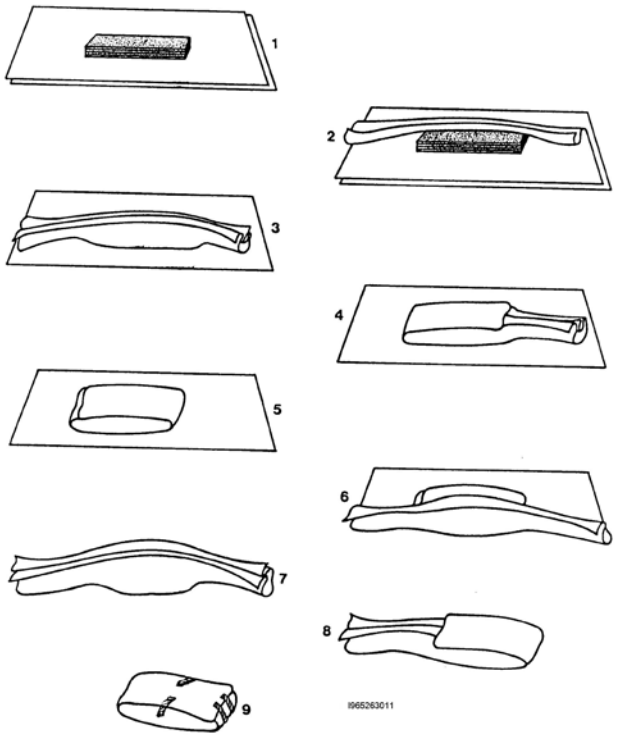

Figure 3–9. Rectangular wrapping method.

Rectangular Wrapping Method	
Step	**Description**
1	Find a helper. It is much easier to rectangularly wrap an item with two people. It takes much practice and experience to rectangularly wrap a large pack properly by yourself.
2	If 54 by 72 inch wrappers are not available, fold two muslin sheets in half lengthwise to make each one a double thickness wrapper. Four layers of muslin are needed to ensure the sterility of package contents.
3	• If using wrappers, place two wrappers on the table. • If using sheets, place one folded sheet on the table with fold on one side, place the other folded sheet on top with the fold on the opposite side.
4	• Place the item being wrapped in the center of the wrapper (or sheets), square sides parallel to the wrapper (or sheets) sides. • Fold one side of the top wrapper, or the fold-side of the top sheet, over the item being wrapped (fig. 3–9, step 1). • Make a cuff by reversing the fold side (fig. 3–9, step 2) back over the item being wrapped.

Rectangular Wrapping Method	
Step	**Description**
5	• Fold the other side of the wrapper, or the open, stitched edge side of the sheet, over the top of the item being wrapped. • Make another cuff (fig. 3–9, step 3).
6	• Fold one side of the wrapper or sheet over the item being wrapped. • Fold the loose ends under (as shown in fig. 3–9, step 4) so they are closest to the package and do not extend below the top of the pack.
7	• Fold the other side of the wrapper or sheet over the item being wrapped. • Again, fold the loose ends under (fig. 3–9, step 5).
8	Complete the wrap by repeating steps 4 through 7 (as listed in this table) with the second wrapper (fig. 3–9, steps 6–9).
9	• On the last fold of this outer wrapper, do not fold the loose ends under the flap. • Fold them back over the top of the item being wrapped, and secure with the appropriate sterilizer tape (fig. 3–9, step 9).

If you must wrap a large number of items using sheets, you can save time by checking each sheet, folding it in half and stacking it on a table before you start actually wrapping. If you pre-fold and stack these sheets, make sure you stack them so that the folded edges alternate from side-to-side within the stack.

No matter the wrapping method you use, *always* put a chemical sterilization indicator inside all packs, sets, and packages you prepare. Get in the habit of performing the final quality check as discussed previously.

Packaging items in peel-packs

Use peel-packs only for relatively low-profile items that will not tear or puncture the paper side of the package. There should be at least a one-inch safety margin from the edges of the package all around the item contained. Pouches are also available in many different widths and lengths. Use peel-pack tubing to package items that are too long for a pouch; peel-pack tubing is available in many different widths.

When putting an item in a peel-pack, make sure the handle or part that should be grasped first is near the end of the pack designed to be opened, if there is a designated open end. This allows the scrub to safely grasp the item when the circulator peels back the sides of the package and presents the contents. When putting more than one item, or an item with many pieces, in a peel-pack, use two peel-packs; one keeps the items together, the other serves as the protective package. Do not forget to place an internal chemical sterilization indicator in all packages, and, since you can see through the plastic side, make sure the color-changing part of the indicator is visible.

When selecting a peel-pack, make sure to choose one large enough to accommodate the item to be packaged (remember the one-inch safety margin). However, *do not* use a peel-pack that is too large. If the contents move around excessively, they can break open the seals; large peel-packs also take up more room in the storage area.

Peel-packs are generally sealed in one of two ways. Pouches may be self-sealing, singe and adhesive flap to close the pouch. If a self-sealing pouch is used, the sealing flaps must not have any wrinkles or air gaps that can allow microorganisms to penetrate the package. Peel-pack tubing should be heat sealed; pouches may also be sealed by heat. Heat sealing involves using a machine to seal the packs by applying enough heat to make the plastic melt and bond to the paper. The machine should not be so hot it melts the plastic and leaves openings or gaps in the surface. Heat sealing is very effective and highly recommended for peel-packs, but the edges of all seals must be inspected to ensure they

are firmly sealed. Some machines provide double-sealing or multiple-sealing lines to offer additional package security.

Using rigid containers

Placing instruments in rigid containers is similar to placing them in pans that are wrapped; you assemble the instruments in the container's wire or mesh basket or pan. The most significant difference is that, when using rigid containers, the instruments *cannot* extend above the basket or pan because they *cannot* contact the container lid. Another difference is that the rigid container is often engraved or otherwise labeled for a specific instrument set. Ensure you use the proper container for each set you assemble. A mix-up can have dangerous consequences if not discovered until it is opened for a procedure. Even if discovered in the processing area, a mix-up of containers leads to much searching and rework.

Before placing the assembled instrument basket or pan into the external container, you must first inspect the container for serviceability. It must be free of any breaks or cracks and then new filters are installed (if the container uses disposable filters) in the container. The specific type filter and the mechanism used to hold it in place varies with each type of container and manufacturer. Some use square plates that span from side-to-side of the container to hold the filter; some use round metal "wagon wheels" with a hub that fastens to a post in the container; and some simply slide into pocket-like devices built into the container. When the filters are securely attached, the instrument basket or tray is placed inside the external rigid container. Do not forget to check for an internal chemical sterilization indicator and perform a final quality check before closing the container.

After putting the lid on the container, engage the locking mechanism or mechanisms and attach the appropriate sealing and security device(s). Place the devices so that any external sterilization indicators can be seen without having to twist or otherwise manipulate them.

Labeling items

Because the contents of packages, sets, external fluids, and linen packs must be identified before they are opened, labeling is an important procedure. Each item should be labeled before it is placed on the sterilization load. The most common methods for labeling the contents of sterile packages are:

- Permanent "magic" markers to write the name on the package tape.
- Pre-printed or stamped adhesive labels or tags.

Rigid containers often use engraved metal plates to identify the contents.

If using a marker to write the label on the tape, ensure it is a permanent-ink type marker that will not run or fade when exposed to high humidity. *Do not* use a china marker or other type wax pencil because wax does not tolerate the heat generated by steam under pressure.

As a *minimum*, the identification information on the label should include:

- The name of the article.
- The initials of the individual or individuals who assembled and packaged the item.

When possible, include the receiving area where the package is to be used on the label (OR #3, ward 2W, L&D, etc.).

In addition to the identification label, each package must have a sterilization control label or expiration label. A sterilization control label generally includes:

- The sterilizer number.
- The load number.
- The Julian date of the day the item was sterilized.

An expiration label usually includes the same information, but *also includes a date the item expires.* These are usually self-adhesive labels, similar to the labels some stores use to affix price tags, which are stamped with the information and applied with a *label gun*. Label guns provide a rapid, accurate, and efficient way to affix sterilization control numbers to each item immediately before sterilization. If this information is written using a marker, and if the item must be sterilized in a different load, the control number can become illegible.

We discuss sterilization control numbers and expiration dates in unit 5, when we look at methods for determining the shelf life of items.

Summary

The first section in this unit presented information on how to clean and decontaminate, sort, inspect, and assemble surgical instruments and supplies. This final section outlined packaging methods and labeling of sterile supplies. Before moving on to the actual sterilization processes, answer the following questions. Review the areas you haven't quite mastered.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

212. Packaging materials for sterilization

1. What is the primary purpose of packaging patient care items?

2. What does the term "permeability" mean in the context of being a desirable characteristic of a package?

3. To obtain a true picture of total packaging costs, what factors do you consider?

4. What is the traditional and most commonly used fabric for non-disposable wrapping materials?

5. What is the cause of linen superheating?

6. What does the term "memory" mean when talking about paper wrapping materials?

7. List some advantages of disposable, non-woven fabric wrappers.

8. What is the primary disadvantage of non-woven fabric disposable wrappers?

9. Describe a peel-pack pouch.

10. What type of rigid container cannot be used in gravity displacement steam sterilizers?

213. Packaging methods and labeling items for sterilization

1. Why is it important to form a wide cuff or flap fold in a wrapper used to package a surgical patient care item?

2. What should you look for when performing the final “quality check” before wrapping any item?

3. When wrapping an item using the diagonal method, which corner of the wrapper should be folded first?

4. When sheets are used for rectangular wrapping, what is done to them before they are wrapped around a set or pack? Why is this necessary?

5. How much “safety margin” should you leave around an item being placed in a peel-pack?

6. How do you place an item in a peel-pack?

7. What restriction is placed on instruments in the internal basket or pan of a rigid container?

8. What is the minimum information included on a package identification label?

9. What does an expiration label contain that a sterilization control label does not?

Answers to Self-Test Questions

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1. (a) Physical removal of organic material or soil from an object.
   (b) The use of physical or chemical means to remove, inactivate, or destroy bloodborne pathogens on a surface or item to the point where they are no longer capable of transmitting infectious particles, and the surface or item is rendered safe for handling, use, or disposal.
   (c) The process of destroying or inhibiting the growth of microorganisms. Disinfection is clearly differentiated from sterilization since disinfection does not kill all microorganisms.
   (d) A sterilization process used to decontaminate patient care items to render them biologically safe for handling and processing.
2. In the operating room during the surgical procedure.
3. The scrub technician; by wiping instruments with a wet sponge or towel, or by soaking the instruments in a basin of sterile water or other locally approved solution ***before*** the scrub removes his or her gown, gloves, and other protective attire.
4. In a manner that will ensure the person in the decontamination area *does **not** have to reach into the container to retrieve them.*
5. To help loosen dried blood and organic matter the scrub technician missed; the presoak also helps prevent these organic substances from drying on the instruments.
6. When no other method is available.
7. (1) Eye and face protection, a full-face shield is recommended.
   (2) Surgical face mask, a high filtration mask is recommended.
   (3) Surgical cap or other permitted hair cover.
   (4) Scrub suit, covered with a liquid-proof gown or apron with long, impervious sleeves.
   (5) Moisture-resistant coverall or similar item is also recommended if spills or splashing is likely.
   (6) Rubber or latex gloves. They should be high enough and strong enough to prevent contact with the solution.
   (7) Water-proof boots or shoe covers should be worn if splashing or fluid pooling on the floor is likely.
8. To prevent microbes from being transmitted via airborne droplets (this is known as aerosolization).
9. (1) Do not immerse the motor in liquid. The motor is cleaned with a disinfectant-soaked soft cloth, and then rinsed using a water-soaked cloth, then dried.
   (2) Leave the air hose connected to the handpiece during cleaning to reduce the likelihood of solution entering the motor.
   (3) Disassemble all accessories and attachments before cleaning. Some attachments may be mechanically cleaned, others may not.
   (4) Lubricate all components according to manufacturer's directions.
10. All contaminated items that cannot be damaged by heat and moisture.
11. The washer-sterilizer washes its contents by filling the chamber with solution and agitating it, and then sterilizes the contents. The washer-decontaminator uses a forceful jet or spray to wash the contents, and then relies on a germicidal detergent for decontamination; but it does not terminally sterilize the contents.
12. Cavitation.
13. (1) Items should be placed in perforated containers such as pans, trays, or baskets.
   (2) Heavy instruments should be in separate trays from lighter ones, or, heavy items should be placed in the bottom of the container, lighter ones on top.
   (3) Sharp or pointed items should be placed in separate containers, or should be placed on top of all other items. They should be arranged so the sharp or pointed areas will not be damaged by contact with other instruments, and so they will not injure processing area personnel.
   (4) Concave surfaces of items should be placed face down, or to the side, to allow the solution to flow through, rather than pool on, the surface.

(5) Open all hinged instruments and disengage ratchets; ringed instruments may be placed on a “stringer” to help hold them open.

(6) Disassemble multi-part instruments as much as possible. Ensure small pieces are safely contained so they will not be lost.

(7) Arrange all items neatly; they should not be simply piled in the container. Do not overload the instrument trays.

14. A water-soluble instrument lubricant.
15. Mineral oil, silicone-based, or petroleum-based lubricants; they interfere with steam, ethylene oxide, and chemical sterilization techniques.

210

1. Put them side-by-side on a rolled towel.
2. Handle them by the handles; lay them on a towel to prevent contact with hard table surfaces.
3. According to size and type (or gauge).
4. A locally developed photographic instrument identification book and/or instrument manufacturer’s catalogs or brochures.
5. To prevent patient injury and avoid delays during surgical procedures.
6. After cleaning and decontamination, and before storage or sterilization; while preparing the sterile field before surgery; during the breakdown of the setup at the end of the operation.
7. To identify defective or low-quality instruments and reject them from service.
8. Any six of the following:
   (1) Check hinges and box locks for cracks and loose pivot pins or screws.
   (2) Check all jaws for proper alignment.
   (3) Check the ratchet closing mechanism for signs of wear and proper function.
   (4) Check for bent shanks; check for proper jaw tension and grip.
   (5) Check needle holder jaws for worn serrations and their ability to firmly hold needles.
   (6) Check scissors for bent or broken tips, burrs or nicks on cutting surfaces, and for sharpness.
   (7) Inspect cutting surfaces on all orthopedic instruments and the jaw alignment and pivot points on all rongeurs and bone cutters.
9. Try to erase it with a pencil eraser. If the “rust” comes off, then the residue is a stain, not corrosion.
10. High mineral content in the cleaning water or steam; removing the instruments too soon, allowing cold air to condense inside the sets; a faulty sterilizer drying cycle leaving excess moisture; using too much of or improper types of cleaning agents.
11. (a) Cleaning instruments with ammonia-based detergents; exposure to steam contaminated by the chemicals facility maintenance personnel use to clean the lime deposits from the steam lines.
    (b) Dried blood or organic material left on the instruments (particularly in hard-to-clean areas); excessive moisture left on instruments due to condensation following steam sterilization; transfer of deposits and scale from improperly cleaned sterilizer chambers or racks to the instrument surfaces.
    (c) Most common cause is prolonged soaking of instruments in saline; also prolonged exposure to blood or corrosive chemical disinfectants; use of excessively alkaline (high pH) or acidic (low pH) detergents for instrument cleaning; mixing dissimilar metals during ultrasonic cleaning and steam sterilization processes.
    (d) Rinsing instruments with mineral-containing tap water; mixing instruments made from different metals in ultrasonic cleaning or steam sterilization loads.
12. Remove the instrument from service and replace it with a serviceable item, if possible.
13. Close instruments with ratchet mechanisms to the first ratchet tooth, not the last, to prevent tension and strain on the lock and tips.

211

1. (1) Use pre-printed “count sheets” to assemble each set.

(2) Use index cards (“cardex system”) that provide processing personnel with all essential information they need to assemble, wrap, and sterilize different packs and sets.

2. Open the jaws and ratchets to allow steam to contact all surfaces of the instrument.
3. To facilitate sterile field setup and instrument counting.
4. To prevent breakage and contain glass fragments if the item does break.
5. Flush them with distilled water to ensure steam is formed inside the lumen; this theoretically will eliminate cool air pockets and sterilize the lumen.
6. To allow adequate steam circulation between fabric layers and to facilitate handling and use during surgery.
7. As close to the geometric center of the pack as possible.

212

1. To maintain their sterility up to the point of use.
2. It must permit the sterilizing agent to penetrate the package and fully contact all surfaces of the items being sterilized and must also allow non-sterile air to escape from the package during the sterilization cycle. Package permeability must allow the sterilant to escape at the end of the cycle, and must not hinder drying of steam sterilized loads or aeration of ethylene oxide sterilized loads.
3. (1) Original cost.
   (2) Number of times of reuse.
   (3) Efficiency of use.
   (4) Labor involved.
4. 140 thread count, unbleached cotton muslin.
5. Lack of moisture (dehydration) in the fibers of the linen caused by a failure to relaunder them after each sterilization process.
6. It refers to a paper wrapper’s tendency to return back to its original, unfolded state each time it is folded or held.
7. (1) Available in different weights, or thicknesses, for various applications.
   (2) Nearly as flexible (memory-free) as cloth wrappers.
   (3) Nearly lint-free.
   (4) Disposable.
   (5) Excellent barriers to microbes and moisture after sterilization.
   (6) Stronger and more tear resistant than paper.
8. Cost.
9. They are made with a layer of paper on one side and plastic on the other. The paper ensures good steam penetration and the clear plastic allows the user to see what is in the wrapper. They come in various sizes and are sealed on three sides with the fourth side left open. This creates a small, flat bag to insert the contents. After the desired item is inserted into the package, the open end is sealed, either with a fold-down adhesive flap or by using a heat sealer.
10. Containers without perforated bottoms.

213

1. To allow circulating personnel to open the wrapper without contaminating the inner, sterile contents of a package.
2. (1) Ensure an internal chemical sterilization indicator is included in the package.
   (2) Look at how the items are arranged.
   (3) Look for any missed stains or rust.
   (4) Be alert for any other discrepancies.

3. The wrapper corner closest to the person doing the wrapping.

4. The sheets must be folded in half, lengthwise to provide four layers of muslin which are needed to ensure package content sterility.
5. One inch from the edges of the package all around the item contained.
6. With the handle or part that will be grasped first facing towards the end of the pack designed to be opened.
7. The instruments cannot extend above the pan or basket because they cannot contact the lid.
8. Name of the article and initials of the individual or individuals who assembled and packaged the item.
9. A date the item expires.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

Do not return your answer sheet to AFCDA.

32. (209) At what stage of the decontamination process is an enzymatic agent often used?
    a. Presoaking.
    b. Initial cleaning.
    c. Mechanical cleaning.
    d. Terminal sterilization.

33. (209) What type of cleaning is the method of choice for instrument and supply processing?
    a. Initial.
    b. Manual.
    c. Presoaking.
    d. Mechanical.

34. (209) Which of the following statements *best* describes terminal sterilization?
    a. A method of processing packaged items for dispensing or storage.
    b. A method of decontaminating items to make them safe for handling.
    c. A process of processing unwrapped items for immediate surgical use.
    d. A process of inhibiting the growth of microbes using strong chemical agents.

35. (209) When should the cleaning of instruments and supplies begin?
    a. During the surgical procedure.
    b. Immediately after the surgical procedure.
    c. When received in the decontamination area.
    d. After decontamination or terminal sterilization.

36. (209) The process of cleaning surgical instruments through the use of high-frequency sound waves generated by an ultrasonic cleaner is called
    a. cavitation.
    b. resonation.
    c. electrolysis.
    d. denaturation.

37. (209) What lubricant is used for most medical instruments with moving metal parts?
    a. Mineral oil.
    b. Instrument milk.
    c. Light machine oil.
    d. Silicone lubricants.

38. (210) When are new instruments thoroughly inspected?
    a. Before they are first used.
    b. After they are used for the first time.
    c. When they begin to show signs of wear.
    d. One month after being placed into service.

39. (210) When inspecting a needle holder, which parts of the instrument should meet first as it is closed?
    a. Tips of the jaw.
    b. Base of the jaw.
    c. Last tooth of the ratchet mechanism.
    d. First tooth of the ratchet mechanism.

40. (210) What is the *most* common cause of pitting on instrument surfaces?
    a. High mineral content of water or steam.
    b. Prolonged soaking of instruments in saline.
    c. Mixing dissimilar metal instruments in the same sterilizer load.
    d. Use of slightly acidic (low pH) detergents for instrument cleaning.

41. (211) Which of the following statements *best* describes how instruments are placed in a pan for sterilization?
    a. Multi-part instruments are reassembled before they are placed in the pan.
    b. Scissors are always covered by a towel and put in the bottom of the pan with tips open.
    c. Heavy retractors are always placed on the bottom of the pan, with delicate instruments on top.
    d. Ratcheted instruments are strung together with the ratchets fully closed and tips facing the same way.

42. (211) Why should glass items be individually wrapped before they are placed in a set for sterilization?
    a. To reduce pitting of the glassware.
    b. To absorb moisture during the sterilization cycle.
    c. To confine the glass fragments if the item breaks.
    d. To prevent the glass from superheating and breaking.

43. (211) If one particular instrument set is recurrently found to be wet after sterilization, what is the most likely cause?
    a. The sterilizer is malfunctioning.
    b. The density of the set is too great.
    c. Items with lumens were flushed with water.
    d. Instrument milk is not being dried before sterilization.

44. (212) Which fabric is acceptable for reusable sterilization wrappers?
    a. 120 thread count cotton/polyester.
    b. 140 thread count cotton/polyester.
    c. 120 thread count unbleached cotton muslin.
    d. 140 thread count unbleached cotton muslin.

45. (212) What is superheating?
    a. The method of bacterial destruction in a dry heat sterilizer.
    b. A condition of excessive heat caused by over-pressurizing a steam sterilizer.
    c. A process that gradually destroys the fibers of fabrics subjected to steam sterilization without being laundered.
    d. A condition of excessive heat inside an instrument set caused by overcrowding of instruments and glassware.

46. (212) In the context of wrapping materials, what is memory?
    a. The tendency of a material to tear or puncture.
    b. The tendency of a material to return to a previous shape.
    c. The ability of a material to act as a barrier to microbes after sterilization.
    d. The ability of a material to allow the sterilant to penetrate and contact all surfaces.

47. (213) Why should you make a “dog-ear” flap or a cuff when wrapping items for sterilization?
    a. To contain loose items and prevent them from being lost.
    b. To provide an area for the tape to stick to and seal the package.
    c. To allow wrappers to be opened without contaminating the contents.
    d. To separate metal-to-metal items and allow for adequate steam penetration.

48. (213) What is the rectangular method of wrapping *predominantly* used for?
    a. Drape packs.
    b. Emesis basins.
    c. Instrument sets.
    d. Medicine glasses.

Please read the unit menu for unit 4 and continue ➔

Student Notes

Unit 4. Sterilization and Disinfection

AS A MEMBER OF THE SURGICAL TEAM, you have an enormous responsibility to provide an environment for your patients that is not only physically clean, but also as free of microorganisms as possible. Obviously, it is impossible to prevent all potential pathogens from entering the surgical environment, but you and your co-workers must use every possible means at your disposal to protect your patients (and yourselves) from possible infection. There are several methods used to control or eliminate infectious "invaders" in the operating room (OR). The two most reliable and effective are *sterilization* and *disinfection.*

Effective sterilization and disinfection of patient care items are the "master links" in the chain of infection control activities performed in the OR. It makes no sense to operate on a patient to correct a problem if the environment and items you use to do so are crawling with pathogens that will result in an infection—which, in turn, will cause greater problems. As a surgical technician, you must have a thorough understanding of the principles and methods of sterilization and disinfection to ensure your patients (and co-workers) remain free from infection.

4–1. Sterilization and Disinfection Processes

The discussion of microbiology and infection control in unit 1 stated that any microorganism is capable of causing an infection (becoming pathogenic) if introduced into an area of the body where it does not normally reside. Since we routinely "invade" the patient's body with instruments and other items, we must make every effort to prevent introducing potential pathogens into susceptible areas.

To ensure surgical patient care items are biologically safe for use on patients, all surgical technicians and nurses must understand the common processes used to render items as biologically safe as possible. Only those individuals who demonstrate a thorough working knowledge and understanding of microbiology, infection control, and sterilization should be entrusted with the processing of reusable patient care items. As a surgical technician, much of your time is devoted to handling, cleaning, decontaminating, assembling, and disinfecting or sterilizing surgical instruments and supplies. It is absolutely essential that you have a thorough working knowledge of these processes.

The following lessons cover the basic purpose, principles, and methods of sterilization and disinfection. They provide a "prep-course" to the follow-on discussions in this unit relating to the primary sterilization methods used in hospitals. You were introduced to many of these topics while you were in technical school; this course expands your introduction.

214. Purpose of sterilization and disinfection

Deep tissues, body cavities, and intravascular areas are considered sterile. This is because they usually only contain resident bacteria that are common to that patient and as such will not normally cause an infection. Surgical procedures involving these areas are considered *invasive procedures*. Because these areas are sterile, any surgical instrument or supply that comes in contact with these areas should also be sterile.

Before you attempt to disinfect or sterilize any object, you should know:

- What each term means.
- Which items we disinfect.
- Which items we sterilize.
- Why we sterilize or disinfect these items.

You should also be familiar with the processes or methods we routinely use to achieve these conditions.

Disinfection

Disinfection is generally defined by three classifications: high-level, intermediate-level, or low-level.

1. *High*-level disinfection kills *all microorganisms except spore-forming bacteria;* the process may also kill spores if the exposure time is long enough and certain other conditions are met.
2. *Intermediate*-level disinfection *kills most microorganisms*, including bacteria, viruses, and fungi, but spores are not affected.
3. *Low*-level disinfection attacks vegetative bacteria, fungi, and the least-resistant viruses.

Regardless of the process used, and since surgical personnel use the absolute definition of sterility, the process of disinfection results in an unsterile item—*never forget that disinfected items are not sterile.*

After items are used on a patient, part of the decontamination process is often called either *terminal sterilization* or *terminal disinfection*. This process is done to *reduce the bioburden* (relative number of microorganisms) of an item to a level that makes the item biologically safe for handling by reprocessing personnel. Items that are terminally sterilized or disinfected require additional cleaning and preparation; they should *not* be directly used on a surgical patient.

Sterilization

The absolute definition of sterilization is: A process that destroys all living microorganisms, including bacterial spores and viruses.

This state of total destruction is technically impossible to scientifically measure; it is impractical to test each and every item after sterilization because the testing would render it nonsterile for patient use. The more technically correct definition is: *A process that provides the highest level of assurance that an item can be expected to be free of viable microorganisms.*

However, in surgery, the goal is to completely destroy all microbial life. So for practical purposes, the absolute definition is acceptable. When an item is “considered sterile” for surgery, it is an absolute term—an item is either sterile or unsterile—there is no such condition as “partially sterile” or “almost sterile.”

For an item to be considered sterile, the process used must be capable of achieving this (theoretical) total destruction. The items exposed to a sterilization process are considered sterile if all mechanical parameters are met and all external and internal sterilization cycle indicators are acceptable. We will discuss these parameters and indicators in greater detail later in this unit.

Purpose

Why do we disinfect or sterilize patient care items? There are two simple answers to this question:

- To prevent microbes from being introduced into the patient where they can cause a surgical wound infection.
- To achieve decontamination and render items used in surgical procedures safe for handling by hospital personnel. This helps prevent the spread of potentially pathogenic microorganisms to other patients, surgical personnel, and environmental surfaces.

Item classification

Ideally, every item used on or coming in contact with a patient would be sterile. Since this is both impractical and impossible, you must consider the purpose or actual use of the item when determining how a particular item should be processed. To help you determine exactly how a particular item should be handled, use the following classification system.

Item Classification for Sterilization/Disinfection	
Classification	**Description**
Critical	Items that enter or come in contact with sterile tissue or the vascular system. These areas of the body are most vulnerable to infection. So, critical items must be sterile. Examples of critical items include, but are not limited to, surgical instruments, implants, needles, and catheters.
Semicritical	Items that come in contact with mucous membranes or non-intact skin (such as an area with a rash). The mucous membranes generally resist spore-forming bacteria, but they are susceptible to other microbes. Semicritical items should be at least high-level disinfected. Examples of semicritical items include anesthesia apparatus, gastro- or colonoscopy equipment, respiratory therapy equipment, and thermometers.
Noncritical	Items that come in contact only with intact skin. Skin is the primary barrier to infection; it resists most microorganisms. Noncritical items may be subjected to intermediate-level or low-level disinfection. Examples of noncritical items include blood-pressure cuffs, tourniquet cuffs, bedpans, linens (not used as drapes), and furniture.

Remember, these classifications reflect the *minimum* requirements; whenever possible or practical—sterilize it!

215. Agents used for sterilization

Sterility is an absolute concept with no margin for error. Remember this when you process surgical items, and keep it in mind during the rest of our discussion. Now that you know what sterilization is and why we do it, you need to know the methods and agents, called *sterilants*, used in hospitals to sterilize items. These methods can be divided into two very general classifications, physical methods and chemical methods. Physical methods include moist heat (steam under pressure), non-ionizing radiation (microwave) and ionizing radiation. Non-ionizing radiation and ionizing radiation are considered non-thermal, physical methods of sterilization. Chemical sterilizing agents include gaseous states of formaldehyde, ozone, and hydrogen peroxide plasma/vapor; they also include liquid solutions of peracetic acid or glutaraldehyde. The chemical sterilization agents used in each hospital vary greatly, but every hospital uses at least one thermal agent —moist heat.

Moist heat

Moist heat, or steam sterilization, is the most common method of sterilization used in hospitals. This type of sterilization uses a sterilizer known as an *autoclave* to deliver moist heat, in the form of steam under pressure, as the sterilant to kill microorganisms. Steam alone is not hot enough to be an adequate sterilant, nor is moisture alone. But, when steam is pressurized, the temperature increases. Steam is water vapor, and adding as much moisture vapor as the pressurized steam will hold results in saturated steam under pressure—an excellent sterilant. This moist heat kills microbes faster than dry

heat by offering a two-fold attack; it destroys the microorganisms by changing the makeup of the cell proteins (denaturing), then coagulating them.

For steam-under-pressure sterilizers to be effective, the steam must attain, and maintain for a specific time, the temperature required to destroy even the most heat-resistant microorganisms. The steam must also contact all surfaces of the items being sterilized. For this reason, substances such as anhydrous oils, greases, and powders (such as talcum or petrolatum ointment) cannot be sterilized by steam because the steam is unable to penetrate them. Steam-under-pressure sterilization is the *method of choice* for sterilizing all items that are not heat or moisture sensitive.

Non-ionizing radiation

Non-ionizing radiation, commonly called microwaves, sterilization currently uses low-pressure steam combined with microwaves to generate very rapid high localized temperatures. Cycle times may be as short as 30 seconds with this type of sterilization. However, technology limitations, such as the requirement to place metal items in a partial vacuum within a glass container, have prevented its practical wide-spread use in medical facilities.

Ionizing radiation

This method of sterilization uses a combination of thermal and chemical energy to destroy microbes. The exact mechanism it uses to destroy these cells is complex and, unless your hobby is nuclear physics, probably beyond your full comprehension. A very simple explanation is that Cobalt 60 generates Gamma rays that deeply penetrate items and generate electrons that destroy the DNA of living organisms, making reproduction impossible. Exposure time is usually between 10 and 20 hours. Experts generally consider ionizing radiation as the most effective method of sterilization. However, like microwave sterilization, ionizing radiation is not currently used in hospitals; the hazards and costs do not make it cost effective for local sterilization. It is predominantly used by commercial medical supply manufacturers. The deep-penetration of the gamma rays allows large, bulky objects, such as cartons of supplies ready for shipment, to be sterilized. This saves these manufacturers a great deal of time and money. Ionizing radiation was probably used to sterilize the disposable supply items such as the gowns and drape packs you use in your OR.

Chemical sterilants

Chemical sterilizing agents are effective, though their effectiveness varies. They can be classified as either liquid agents or gaseous agents. When using liquid agents, items must be completely immersed in the solution. This may be done by simply immersing the item in a basin containing the solution, or it may be accomplished using an automatic cycle and specialized equipment. Gaseous agents are used in specially designed sterilizers under specific conditions. For any chemical agent to be a sterilant, the agent must contact all surfaces of the items for a defined time of exposure.

Chemical sterilizing agents are considered hazardous chemicals by the Occupational Safety and Health Administration (OSHA). Ensure you wear eye protection, splash protection, and gloves when working with them. Some, such as ethylene oxide, also require respiratory protection. Always ensure you follow specific local policies and guidelines outlined by your hazardous communication program.

Hydrogen peroxide plasma or vapor

Hydrogen peroxide is used as a sterilant by converting it from a liquid to either a vapor or to plasma. A hydrogen peroxide *plasma sterilizer* (e.g., the J&J Sterrad™) subjects the liquid hydrogen peroxide to radiofrequency energy to form plasma. Air is evacuated from the chamber, the liquid hydrogen peroxide enters the chamber and is vaporized, and then radiofrequency energy converts the vapor to plasma within the chamber. The plasma sterilizer operates at about 104° F and sterilizes in about an hour.

A hydrogen peroxide *gas plasma sterilizer* passes the liquid hydrogen peroxide through an electromagnetic field to generate its plasma. This plasma is then introduced to the chamber. The gas

plasma sterilizer operates at about the same temperature as the plasma sterilizer, and sterilizes unwrapped items in about 30 minutes, and wrapped supplies in about 90 minutes.

In a hydrogen peroxide *vapor phase sterilizer*, a vacuum is created in the chamber, and then a cold vapor of hydrogen peroxide is introduced. It sterilizes between 39 and 46° F; the time varies.

The major advantages of this sterilization method are that the process is non-toxic and it sterilizes at cool temperatures. At the end of the sterilization process, the sterilant reverts to the byproducts of oxygen and water vapor which can be safely vented into the room air. The process leaves no toxic residue, so aeration of the contents is not required. Because plasma sterilization is dry, it is safer for many instruments and corrosion does not occur on metals. The low temperatures allow for sterilization of heat sensitive items such as endoscopes and other fiberoptic devices. A major advantage is that the sterilizer is generally self-sufficient. All a facility needs is a standard electrical outlet and a large enough location; you plug in the unit and it is ready for use.

The major disadvantage of hydrogen peroxide sterilization is that many items cannot be sterilized by this method. Nylon becomes brittle after repeated exposure, liquids cannot be sterilized, and cellulose-based items (such as linens and paper) are damaged by hydrogen peroxide vapor sterilization. Sterilization wrappers must be plastic-based, such as polypropylene. Metal trays also block the radiofrequency waves in a plasma sterilizer, so special containers must be used. As in all gas sterilization methods, the items being sterilized must be thoroughly clean and dry.

Peracetic and acetic acid solutions

Peracetic (technically peroxyacetic) acid solutions are also used as sterilants. These solutions are liquid sterilants which means items must be fully immersed in the solution to achieve sterilization. One method (Steris™) mixes peracetic acid with hydrogen peroxide and an anti-corrosive/buffer powder in a specially designed table-top or sterilizer. The sterilizer automatically mixes the solution to about 0.2 percent peracetic acid, heats the solution to between 122 and 132° F, immerses the contents for a specified period, then rinses the now sterile contents—all in about 30-minutes.

Advantages of this method of peracetic acid sterilization include:

- It is relatively fast when compared to most other cold-sterilization methods.
- Almost any type of immersible surgical instrument can be processed.
- The cycle is almost entirely automatic, minimizing the chances of human error.
- The sterilant is single-use, so there is no possibility of cross-contamination.
- The solution discharged at cycle completion is not considered hazardous even by the strictest current laws.

Disadvantages of this method of peracetic acid sterilization include:

- The item for sterilizing must be capable of total immersion in the solution.
- The solution must contact all areas throughout the cycle. This makes sterilization of scopes and other endoscopic instruments with small channels or lumen difficult to sterilize.
- The item is not packaged, so must be used within a short period after sterilization (no shelf life).

Another method used in hospitals mixes acetic acid with a salt solution to provide a cold solution sterilant (Bionox™). The instruments are immersed in the solution for the manufacturer's recommended time, usually about 20 minutes.

Glutaraldehyde solutions

Glutaraldehyde solutions have been used primarily as high-level disinfectants (more on this later), but are capable of sterilizing items. It works by denaturing the cells, but acts very slowly on spore-forming bacteria. It takes a *minimum* of 10 hours direct exposure to most glutaraldehyde solutions

before an item can be considered sterile. Glutaraldehyde may be packaged as two-part solutions; you must mix the two chemicals to "activate" the solution. Glutaraldehyde may also be packaged full-strength, or in concentrations that must be mixed. Glutaraldehyde is used multiple times in some facilities. After it is dispensed, the container is labeled with the type (brand name) of glutaraldehyde, and expiration date, and the name or initials of the person dispensing or mixing the solution. If it is reusable, a test strip may be used to ensure the solution is still potent. Always follow the manufacturer's instructions, particularly when mixing the solution, sterilizing an item, and determining the date of expiration.

216. Basic principles of disinfection

Sterilization is the method of choice for all surgical supplies, equipment, and instruments because it destroys all pathogens—and all other living organisms as well. In an ideal world, everything in the OR would be sterile; if all organisms were destroyed, infection would be impossible. Many non-surgical people believe this is the case. In reality, many items or surfaces can not be sterilized. In some cases, it is simply not practical and, in other cases, sterilization damages or destroys the item. To render items and surfaces that cannot be sterilized as biologically safe as possible, surgical personnel use a process known as disinfection.

We looked at some disinfecting agents earlier in this unit. This section is designed to further your knowledge of disinfection. The lesson covers the basic principles of disinfection and the basic procedure for disinfecting instruments that cannot be sterilized.

Like most areas of infection control, certain principles apply to disinfection. These principles are generally outlined as guidelines and are based on numerous factors that influence the disinfection process.

Basic rules of chemical disinfection

Certain variables must be considered for all procedures of chemical disinfection, they include:

1. The number and types of microorganisms (particularly their resistance) determine the effectiveness of a chemical agent. As a rule, the greater the number and the more resistant the type of microbes, the less effective the disinfecting agent is.
2. Disinfectants vary in their level of effectiveness according to the makeup, or concentration of, the chemical agent and the manner in which it is used. If the concentration is diluted, the effectiveness decreases; an agent that is wiped-on and allowed to dry is not as effective as the agent would be if the item were completely immersed for an extended period. In addition,
    - The solution must be of sufficient strength to be lethal to the microorganisms for which it is intended.
    - The disinfectant must contact the entire surface of the item.
    - The exposure period must be accurately timed and consistent for bactericidal effect.
    - The disinfectant must be economical and safe for patients and personnel.

Factors determining effectiveness

The specific components of a chemical agent, and many other factors, combine to determine the effectiveness of the particular agents in producing disinfection. Because the process of chemical disinfection requires an interaction between the agent used and the microorganisms involved—the agent must destroy the microorganisms—the effectiveness of each agent varies. Consider the factors discussed below when selecting the chemical agent and procedure to use for disinfecting specific items.

Cleanliness of item or surface

The first step in chemical disinfection is cleaning, or the removal of visible gross contaminates. All items must be cleaned and dried before they are chemically disinfected. The active ingredient of

certain disinfecting agents is inactivated by body proteins, levels of pH, or residual soaps. Contaminated items require special preparation to control the massive microorganism population. If the chemical disinfectant is diluted with a large amount of organic material or residual cleaning liquid is present on the object to be disinfected, the agent's concentration and effectiveness is decreased. A clean surface not only decreases the number of microorganisms and prevents dilution of the disinfecting agent, but it also prevents coagulation of an outer coating of protein that, in turn, prevents penetration of some chemicals to the item's surface.

Type of microorganisms

The type of microorganisms to be dealt with must be considered. Most chemical disinfectants control or destroy vegetative bacteria. However, few chemical disinfecting agents control the resistant forms. Tubercle bacillus, enteroviruses, and most fungal spores occupy an intermediate position between the vegetative bacterial forms and the bacterial spores with regard to resistance.

Number of microorganisms

The number of microorganisms in a colony also determines the effectiveness of chemical disinfection for two reasons. First, because of the mass effect of numbers— the more microorganisms present the longer it takes the disinfectant to destroy them. Second, within any colony of large numbers of microorganisms, there are individual microorganisms that will be more, or less, resistant to destruction by a particular chemical agent. Large colonies of microorganisms are more likely to contain greater numbers of resistant organisms. This is why it is so important to clean items before they are disinfected. Cleaning decreases the number of microorganisms by removing those contained in the gross contaminants.

Type of object or material

Because chemical disinfection is based on a chemical reaction, adequate exposure of the entire surface of the item to the chemical agent is required. The best way to do this is with liquid agents and articles that are disassembled. Tubing and catheters also require special attention to ensure that both the inner and outer surfaces are in complete contact with the chemical agent. To do this, submerge the tube or catheter in the disinfectant solution and then force the solution through the lumen using a syringe.

Agent strength or concentration

Each chemical agent has an ideal concentration that the manufacturer suggests is required for a specific effect. Some solutions evaporate and the concentration of the agent decreases; other agents increase concentration with evaporation. Chemical compatibility is occasionally important because the concentration of some germicides is decreased by acidity, alkalinity, or oxidation reduction properties. The presence of hard water interferes with the effect of certain germicides. One of the reasons it is important to thoroughly dry all items or surfaces to be disinfected is because the added moisture dilutes the concentration of the disinfectant, reducing its germicidal action. Another reason is that moisture drops often contain air bubbles that can prevent the concentrated agent from reaching all areas of the surface.

Time requirements

All chemical disinfecting agents require time to kill microbes. The longer an item is exposed to the disinfecting agent, the more microbes are killed. Therefore, all agents are more effective as exposure time is increased. The time required for effective disinfection also depends on:

- The microorganism to be controlled.
- The number of microorganisms involved.
- The ability to expose all parts of the item to the agent.

Time is not only important for bactericidal effect, but also to keep corrosive agents from damaging rubber or plastic goods.

Temperature

The temperature of a disinfectant solution influences its effectiveness. Normally, the higher the temperature, the faster a germicide reacts (and destroys microbes) because the heat of the solution speeds up the chemical reactions that destroy the cells.

Use of containers

Containers used for disinfection should be sterilized between uses to ensure no microbes are present when the disinfecting agent is mixed. Always keep the container covered to prevent the solution from evaporating and dust particles from settling on the solution surface. Plastic containers are used to contain disinfectants because many chemical disinfectants corrode metal surfaces.

Disinfecting surgical instruments

Now that you know the basic principles of disinfection and are aware of the factors that influence the effectiveness of chemical disinfection, it is time we look at how they are used.

The specific procedure for disinfecting instruments is usually listed on the bottle containing the agent. The instructions provided by the instrument manufacturer must also be considered. Chemical agents used for disinfection are primarily liquids. Most disinfectants require immersion of the instrument. The basic steps for disinfecting articles are listed in the following table.

Steps for Disinfecting Articles

Step	Discussion
1	Disassemble, if possible, the articles to be disinfected to allow disinfectant to contact all surfaces.
2	Thoroughly clean and dry all components of the articles: • Use a cleaning agent that leaves no residue, and pay particular attention to removal of blood and other organic matter from instrument surfaces. • Apply friction to remove soil; use brushes to clean the lumens of tubular instruments. • Change the cleaning solution often if several instruments are washed to prevent gross contamination of the cleaning bath.
3	After cleaning, rinse the articles thoroughly with water.
4	Allow the articles to air dry. You may be able to speed up the process by using suction or air to “blow dry” the items.
5	Completely submerge the articles in the disinfectant solution. • The solution must contact all surfaces of the instrument; therefore, all lumens need to be flushed with the disinfectant using a syringe (be sure to open all stopcocks and channels as well). • The instrument must be dry before immersion in the disinfectant to prevent dilution of the agent, which decreases the concentration and germicidal action. • Cover the container to prevent evaporation and airborne contamination of the solution, as well as to contain any vapors or fumes.
6	Expose the articles to the disinfectant for the prescribed period of time. • Start timing as soon as the articles are submerged and all surfaces are in contact with the disinfectant. • Refer to the disinfectant manufacturer’s instructions for proper exposure periods.
7	Remove the articles when the specified time has elapsed.
8	Rinse thoroughly with sterile water for irrigation. This is necessary to remove any chemical residues that may irritate, inflame, or even burn a patient’s tissues.

Always wear gloves when handling a disinfected instrument; to not only prevent re-contaminating it, but also to protect yourself.

Remember, these are just basic guidelines. You must always follow local policies, procedures, and any applicable manufacturer's guidelines to ensure both patient and hospital personnel safety when disinfecting patient care items.

217. Selecting agents used for disinfection

The chemical disinfecting agents discussed in this lesson are those used to reduce the bioburden of inanimate objects such as instruments and furniture. You will notice some of them are also used as sterilants, but the exposure period and other parameters differ.

Like chemical sterilization agents, chemical disinfectants are considered hazardous chemicals by OSHA. Ensure you wear eye protection, splash protection, and gloves when working with them. Some, such as formaldehyde, may also require a special ventilation hood or respiratory protection. Always ensure you follow specific local policies and guidelines outlined by your hazardous communication program.

As a surgical technician, you must disinfect many surgical items and surfaces during the course of your duty day. Before you begin to disinfect an item, you must select the proper chemical agent for use on the particular item you are disinfecting. To help you select the agent, you should understand some general characteristics and properties of disinfectants, and be familiar with some of the more frequently used agents.

Disinfectant characteristics

Although some germicides produce sterilization under some circumstances, most chemical agents achieve only disinfection because the resistant microorganisms, such as spores and some viruses, are not destroyed. All chemical agents (including disinfectants and sterilants) have to be approved by the FDA (Food and Drug Administration) and registered with the Environmental Protection Agency (EPA) before they are approved for sale. To be classified as a disinfectant by the EPA, a chemical agent has to be proven effective against three highly-resistant bacteria: *Staphylococcus aureus*, *Salmonella choleraesuis* (bacteria linked to enteric fever), and *Pseudomonas aeruginosa*. The product label has to identify exactly what type of microorganisms the agent is effective against. Agents must be checked monthly for outdates and expirations. Agents that destroy all forms of vegetative, or growing, bacteria may be labeled as disinfectants, germicides, or bactericides. Stronger agents designed to penetrate the waxy coating of the tubercle bacilli and destroy it are known as *tuberculocidal* agents. Those that kill fungi are *fungicides*, virus killers are *virucides*, and spore destroyers are *sporicides*.

Agents labeled *tuberculocidal* are generally effective against the HIV virus; some agents are specifically labeled as HIV virucidal. It is difficult to test a germicidal's effectiveness against Hepatitis B (HBV) because HBV survives exposures to many disinfectants. Because of its resistance, you should use the strongest available decontamination method available for suspected exposure to this virus; ideally, any items exposed to HBV should be sterilized. Except for the chemical agents that are used as sterilants, the majority of liquid disinfectants are ***not*** sporicidal.

Because no chemical agent is ideal for all situations, you should be familiar with the properties an ideal disinfectant would possess, if there was such an agent, so you can select an agent that has as many of these properties as possible.

Properties of an ideal disinfectant

An "ideal" disinfectant would:

- Be *broad spectrum.* A broad spectrum agent is effective against a wide variety of microorganisms. It kills or irreversibly inactivates all vegetative bacteria, fungi, and viruses.
- Demonstrate a rapid germicidal action.
- Be effective in the presence of organic or inorganic foreign matter.

- Not be affected by physical and chemical changes. This means that the ideal agent would be equally effective under all acid-alkaline conditions and temperature ranges would mix well with and remain active in hard water, and would not be deactivated by detergents or other substances.
- Not be absorbed by gauze or fabrics.
- Not accumulate in the environment (would be biodegradable) after use.
- Be non-toxic to man, animals, or the environment.
- Not chemically or physically alter surfaces to which it is applied (non-damaging).
- Have a long storage life without being physically or chemically altered.
- Have residual germicidal effects. The agent inhibits the growth of microorganisms after treated surfaces have dried.
- Be easy to mix (dilute) and use.
- Be effective in low concentration so dilution has minimal effect on germicidal action.
- Be equally effective in single-use dilution on all types of surfaces.
- Be virtually odorless.
- Be economical to use.

No manufacturer has been able to develop a chemical agent that meets all the criteria we just outlined. Therefore, when selecting a disinfecting agent, you must select one that has as many of these properties as possible based on the type and population of microorganisms to be killed, and on the intended use of the disinfectant.

Commonly used disinfecting agents

To help you select the most appropriate disinfectant, several of the most commonly used disinfecting agents are described below. Although there are many chemical agents used as hospital disinfectants, the ones discussed below are the most common.

Alcohol

Alcohol—either ethyl or isopropyl—is useful as a disinfectant in concentrations of 70 to 95 percent. Alcohol kills vegetative bacteria, pseudomonas, and fungi after about 10 minutes of exposure. It kills tubercle bacillus and most viruses after about 15 minutes. Alcohol is classified as an intermediate-level disinfectant, and may be used to disinfect semicritical items. Alcohol is also sometimes used as an antiseptic.

Advantages of alcohol are related to its fairly rapid action and fast evaporation times. It is relatively nontoxic, easy to use, and inexpensive. Because alcohol evaporates quickly and leaves no residue, it is commonly used to damp-dust environmental surfaces. When used in this way, it should be allowed to evaporate or “air dry” for best effectiveness.

Disadvantages of alcohol are related to its effects on people and items; it is also flammable. Alcohol is irritating to open wounds and skin lesions, and prolonged use dries the skin; wear gloves and eye protection when using it. Alcohol is corrosive to some metals and other materials. Frequent or long exposure hardens and swells some plastics. *Do not use alcohol on lensed instruments because it dissolves the cement holding the lens in place.* When used to disinfect metal instruments, 0.2 percent sodium nitrate may be added to alcohol to reduce its corrosiveness. Alcohol is volatile; it is highly flammable and it loses its germicidal capability as it evaporates and its concentration drops below 50 percent. Alcohol is also inactivated by organic material, and it will not penetrate many oils. Its effectiveness against the HBV virus is sporadic, so it should *not be used* if this virus is known to be present.

Iodophors

Iodophors are solutions containing a mixture of iodine and detergent. Depending upon the concentration of the solution, iodophors kill vegetative bacteria and pseudomonas after 10 to 20 minutes exposure, and are tuberculocidal and virucidal after 20 minutes at high concentrations (450 parts per million (ppm) iodine). Iodophors are classified as low- to intermediate-level disinfectants, again depending on the concentration of iodine. Iodophors are most frequently used as antiseptics.

Advantages of iodophors are related to their low toxicity and broad-spectrum effectiveness. By mixing the iodine with a detergent, the solution is rendered nontoxic, non-staining, and non-irritating *unless the individual exposed to it is allergic to iodine.* The detergent also increases the biocidal activity of the iodine. Iodophors dry more slowly than alcohol, so the exposure time; thereby the effectiveness, is also increased. Iodophors can be used to disinfect instruments at higher concentrations, but, like alcohol, 0.2 percent sodium nitrite has to be added to the solution to prevent corrosion of metal. Iodophors are useful for housekeeping activities, such as cleaning floors, walls, and furniture, because they clean as well as disinfect the surfaces.

One of the major drawbacks of iodophors is that the iodine stains porous surfaces such as linens and certain plastics. This staining is reduced, or is temporary, by the added detergent, but is still a problem on some items. Iodophors also corrode some metals. Some iodophors are rendered ineffective by organic soil, hard water, or heat. Another disadvantage is that although frequently used as a skin antiseptic, iodophors cause chemical burns if allowed to remain in contact with the skin for prolonged periods. Some people are allergic to iodine or iodine-containing compounds and have severe allergic reactions from even slight exposure to the chemical.

Chlorine compounds

Sodium hypochlorite, more commonly known as household bleach, is an effective low-level disinfectant in concentrations from 1 to 5 percent. It is mainly used as a sanitizing agent for spot cleaning floors and furniture. Chlorine in high concentrations can be bactericidal, fungicidal, tuberculocidal, and virucidal to many viruses, including HIV and HBV. One chlorine compound (*sodium dichloroisocyanurate*) has a lowered pH to increase its microbial effectiveness. Chlorine compounds act rapidly, leave no residue, are easy to use, and are inexpensive.

Disadvantages are numerous. Chlorine compounds usually have an objectionable odor, are very toxic to skin, eyes, respiratory tract and mucous membranes, and are corrosive to many metals and plastics. They are not used for disinfection of surgical instruments. Chlorine compounds are seldom used in the OR or sterile processing.

Phenolics

Phenolics are derived from phenol (phenolic or carbolic acid), which is obtained from coal tar. Pure phenol is extremely caustic to tissue and is rarely used. However, many of the housekeeping detergent-germicides used today are phenol-containing compounds. Staphene™, Hydrosol™, Amphyl™, and Vesphene™ are examples of common phenolic agents used in the OR. In proper concentrations, phenolics are low-level disinfectants, and are capable of killing vegetative bacteria, fungi, tubercle bacilli, and some viruses, but *not* spores.

Advantages are many. Phenolics are easy to use, economical, stable, noncorrosive to environmental surfaces, and remain active after mild heating or prolonged drying. Dry surfaces previously treated with a phenolic compound, which are moistened, again, will once again become bactericidal due to the residue left by the agent. Because of this residual germicidal action, phenolic detergent-germicides are widely used in the OR and Sterile Processing and Distribution (SPD) to clean and disinfect environmental surfaces. They are the agents of choice when dealing with fecal contamination (*E. coli*).

Disadvantages are primarily related to toxicity. Phenolic compounds are toxic and are not used on porous materials, rubber, and some plastics. They are also highly corrosive and, if used as an

instrument disinfectant, should be mixed with 0.5 percent sodium bicarbonate to reduce metal corrosion. Skin and mucous membrane contact with phenolic compounds is irritating, so always wear protective gloves and face protection when handling these agents. The capability of phenolics to reactivate after drying, coupled with their skin/membrane irritation properties, make phenolics *unsuitable for disinfecting instruments that will contact skin or mucous membranes,* such as anesthesia equipment. Phenolics may also have an unpleasant odor.

Formaldehydes

This agent is used in concentrated solutions of 37 percent if mixed in water (aqueous formalin), or 8 percent if mixed in 70 percent isopropyl alcohol (alcohol formalin). Formaldehyde mixtures can be used to attain high-level disinfection of instruments; 0.2 percent sodium nitrate is added to reduce corrosiveness. Formaldehyde is bactericidal and fungicidal after an exposure period of five minutes, and is tuberculocidal and virucidal after 10 minutes (in alcohol) or 15 minutes (in water). It is sporicidal after 12 hours.

Disadvantages of formaldehyde are related to its toxicity. The solution is irritating to the skin, eyes, and mucous membranes; gloves and face protection must be worn when using it. Instruments must be thoroughly rinsed in sterile water after disinfection, and items that may absorb the solution should not be disinfected in formaldehyde. The fumes are highly toxic to man and prolonged inhalation must be avoided. In fact, the fumes are so toxic that formaldehyde is *not suitable* for housekeeping use.

Glutaraldehydes

An aqueous (mixed with water) solution of glutaraldehyde—in a concentration of at least 2 percent—can be used for high-level disinfection of endoscopes and other lensed instruments. Glutaraldehyde disinfection is acceptable for semicritical items, and is sometimes used on critical items if sterilization is not possible. Glutaraldehyde is a broad spectrum chemical disinfectant that kills vegetative bacteria, viruses, fungi and tubercle bacilli within 10 minutes at room temperature. It is sporicidal after an item has been exposed for 10 hours.

Advantages are numerous. Glutaraldehyde is noncorrosive to lensed instruments and is safe for use on most rubber and plastic items. Some glutaraldehyde solutions also remain effective for extended periods, and can be reused if kept in closed containers. This agent remains effective in hard water, is easy to use, contains a rust inhibitor, and acts very rapidly. Cidex™ and Sporicidin™ are the two most common brands of glutaraldehyde solutions used in hospitals. Both of these solutions have a limited shelf life after they are prepared. Follow the manufacturers' specific recommendations.

Disadvantages are also numerous. Contact with the solution can irritate or burn the skin, eyes, and mucous membranes. Gloves and face protection must be worn. The fumes also irritate the eyes and respiratory tract. For these reasons the container should be kept covered when not in use and it should be used only in a well-ventilated area. All items exposed to glutaraldehyde must be thoroughly rinsed with sterile water *before* use to prevent tissue irritation or burns. Glutaraldehyde solutions are also absorbed by some materials, particularly woven polyesters and should not be used to disinfect these items.

Quaternary ammonium compounds and mercurial compounds

Quaternary ammonium compounds, commonly called *quats,* can achieve low-level disinfection after an exposure period of at least 10 minutes. Benzalkonium chloride (Cetylcide™) is the most commonly used quat disinfectant, but it is rarely used. The "quat" solutions, in proper concentrations, are effective in destroying vegetative bacteria, but the length of exposure time required limits their usefulness.

Disadvantages of quaternary ammonium compounds far outweigh their advantages. They are *ineffective* against the tubercle bacillus, spores, and viruses. They are neutralized by soaps and detergents. Fabrics absorb the "quats" from a solution and rapidly dilute the concentration below its "kill" level. Hard water reduces its effective concentration. These compounds are also deactivated by

organic material. Quaternary ammonium compounds are also corrosive, though the corrosiveness can be reduced by adding 0.2 percent sodium nitrate.

Mercurial compounds inhibit the growth of microbes, but do not kill them. They are bacteriostatic, not bacteriocidal, so they are not suitable for hospital disinfection.

Both mercurial compounds and quaternary ammonium compounds are generally ineffective. Their disadvantages far outweigh their advantages, so you should not select them for use in surgery or SPD unless they are the only solutions available.

You can see there are a wide variety of chemical agents used in the OR and throughout the hospital for disinfection purposes. The main things you need to remember when handling these agents are:

- Always read and follow the manufacturer's instructions on the container label.
- Always follow all local policies and procedures regarding safe use of chemical disinfectants.

Summary

This section covered the "foundational information" about the processes we use to help provide infection control in the surgical arena. It started by defining sterilization and disinfection, went on to define the purpose of each method, and then provided a classification system of items based on their physical contact with the patient. The physical and chemical agents used for sterilization were covered next. The section finished with a look at the various agents used for disinfection of inanimate objects.

Before we move on to the most common method used to sterilize items in the hospital, answer the following questions.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

214. Purpose of sterilization and disinfection

1. What is the absolute definition of sterilization?

2. When do you consider an item to be sterile?

3. List and define the three levels of disinfection.

4. State two reasons why we sterilize patient care items.

5. What classification includes anesthesia apparatus, gastro- or colonoscopy equipment, respiratory therapy equipment, and thermometers?

6. What is the minimum sterilization/disinfection process that items in question 5 should be subjected to *before use*?

215. Agents used for sterilization

1. What acts as the sterilant in a steam sterilizer?

2. Why aren't anhydrous oils, greases, ointments, or powders steam sterilized?

3. What is the method of choice for sterilizing items that are *not* heat or moisture sensitive?

4. What types of items are commonly sterilized by ionizing radiation?

5. List the *advantages* of hydrogen peroxide sterilization.

6. List the *disadvantages* of hydrogen peroxide sterilization.

7. List some *advantages* of peracetic acid as a sterilant.

8. For how long must an item be immersed in most glutaraldehyde solutions before it is considered sterile?

216. Basic principles of disinfection

1. Name two factors related to microorganisms that determine the effectiveness of a disinfectant?

2. What causes disinfectants to vary in their level of effectiveness?

3. What is the first step in the disinfection process? Why is this necessary?

4. What type of bacteria do most disinfectants destroy easily?

5. How does the number of microorganisms affect disinfection?

6. Why is it important to thoroughly dry all surfaces or items before they are disinfected?

7. How does time affect disinfection?

8. How does increasing the temperature of a disinfectant solution normally increase the rate of microbial destruction?

9. Of what material are disinfectant containers made? Why?

10. What is the first step in preparing items for disinfection?

11. What must be done to instruments with lumens or channels to ensure all air pockets are removed and the disinfectant contacts all surfaces?

12. When does the timing cycle for disinfection begin?

13. What should be used to rinse items after they have been disinfected, but before they are used on a patient?

217. Selecting agents used for disinfection

1. What three microorganisms must a chemical agent be proven effective against to be classified as a disinfectant by the EPA?

2. Why should items exposed to the Hepatitis B virus be sterilized instead of disinfected?

3. What makes an agent broad spectrum?

4. How long does it take alcohol to kill vegetative bacteria, pseudomonas, and fungi?

5. How long does it take alcohol to kill tubercle bacillus and most viruses?

6. Why should you not use alcohol on lensed instruments?

7. What is a solution of iodine and detergent called?

8. What are some of the reasons iodine is mixed with a detergent?

9. What disinfecting agents leave a residue that is reactivated when the treated surface becomes moist?

10. a. List some advantages of glutaraldehyde solutions.

    b. List some disadvantages.

4–2. Steam Sterilization

As previously mentioned, steam sterilization is the most common method of sterilization used in hospitals. It is also the most cost effective, efficient, and reliable method.

You are routinely required to prepare items for steam sterilization, and must know how to operate a variety of steam sterilizers. It is essential that you become thoroughly familiar not only with the theory behind this method of sterilization but also the basic principles and requirements of effective steam sterilization. In addition, you need to know some of the advantages and disadvantages of steam sterilization; common types and operating principles of different sterilizers; proper loading and unloading; operator maintenance techniques; and, finally, some of the common mistakes that are made during steam sterilization processes.

218. Theory, principles, and basic conditions for steam sterilization

This lesson focuses on steam sterilization. The discussion begins with the theory behind, principles of, and basic conditions for steam sterilization.

Theory of steam sterilization

Most authorities believe that the “moist heat” provided by steam under pressure kills microorganisms by using heat energy to disrupt the structure of the cell and coagulating its protein. This process is called *denaturation;* it changes the physical properties of microbial cells and destroys the reproducing and life-sustaining activities of the cell proteins. Continued exposure to moist heat eventually results in coagulation of all cellular proteins and the death of the cells.

The moist heat used in steam sterilization is provided by *saturated steam*. Saturated steam is steam that is “almost wet” and contains a maximum amount of water vapor. This type of steam condenses into water when it contacts a cool object, releasing a great amount of heat. An example of this action is seen when you blow your warm breath against a cold window pane or when you pull an ice-cold glass out of the freezer. The glass “fogs-up” due to condensation of the water vapor as your warm

breath or the warm room air contacts the cold glass surface. If you leave the ice cold glass exposed to the warm, moisture-containing air long enough, it eventually gets as warm as the air due to the heat energy transfer caused by condensation. This transfer of heat energy by condensation is a simple illustration of the key to the effective steam sterilization.

When placed in a steam sterilizer, the cooler item absorbs heat as the moisture in the saturated steam condenses. This continues until the item being sterilized reaches the same temperature as the surrounding steam, at which point condensation stops and no further heat transfer occurs. For unwrapped metal instruments, this conductive-condensation heat transfer process takes a relatively short period of time because the steam directly contacts the bare metal. For large instrument sets, packs, and other wrapped items, the process takes considerably longer. When a pack is sterilized, each successive layer must be penetrated by the saturated steam and heated as the steam condenses on the cool material. The process continues until all areas of the pack have been heated to the same temperature as the surrounding steam. This is why different sterilization exposure times (discussed later) are needed for different items.

Principles of steam sterilization

In order to effectively sterilize items using saturated steam-under-pressure, the following principles apply.

Temperature of the steam

The temperature of the steam throughout the load must be high enough to destroy the most resistant microorganisms in the time allotted for sterilization. You know that bacterial spores are highly resistant to destruction; many can withstand temperatures above that of boiling water (212° F or 100° C). The relationship of temperature to spore killing power is critical. When the temperature is high enough to kill all microorganisms over a specified exposure period, this time/temperature combination is known as the *thermal death point*. Steam *temperature*, not pressure, is the critical factor. Pressure is important only because it is used to raise the temperature of the steam high enough to kill all microbes. Pressure *does not* otherwise contribute to the microbial killing action.

Steam saturation

The steam must be saturated so it will quickly release its heat through condensation when it contacts a cool object. Steam is saturated when it is the proper temperature and pressure resulting in just below 3 percent moisture. Moist heat kills organisms at lower temperatures more effectively than dry heat does because the moisture is absorbed by the cells and speeds up the thermal reaction that ultimately results in cell destruction.

Purity of the steam

The steam must be “pure.” In other words, it must be a solid stream of steam, containing no excess air, no liquid water drops, and no solid particle contaminants. Air-forming “pockets” in the sterilizer is one of the most serious problems in steam sterilization. If air pockets form, items in these pockets may not reach the thermal death point because they lose the benefit of heat conduction through condensation. If too much liquid is in the steam, too much condensation occurs and heat exchange is ineffective. The effects of solid particles (such as rust) on sterilization are varied; they may reduce the heating and penetrating power of the steam, and they may discolor the items being sterilized.

Penetration of the steam

The steam must penetrate all permeable surfaces and have free access to all items being sterilized. The steam must directly contact all areas or surfaces of the item being sterilized. This is the reason greases, powders, and oils *cannot* be sterilized using steam—the steam cannot penetrate, contact all areas, and transfer heat via condensation.

These basic principles form the “ground rules” for all steam sterilization methods. Our next subject expands on these principles by focusing on the primary conditions necessary for effective steam sterilization.

Primary conditions for effective steam sterilization

To achieve reliable steam sterilization, certain requirements must be consistently met in every steam sterilization cycle.

Steam regulation

The sterilizer must be regulated so the correct temperature is reached, and the temperature must be maintained at least until the thermal death point of microorganisms is reached. A temperature too low does not sterilize; one too high can damage certain materials. Some spore-forming bacteria can survive at 240° F for up to three hours. However, adding 10° F and moisture is lethal. No known living organism can survive exposure to 250° F saturated steam for longer than 15 minutes. For this reason, *minimum exposure* to a temperature of 250° F (121° C) for 15 minutes is the generally accepted standard. Higher temperatures reduce the required exposure period.

The time period also varies depending upon the item being sterilized. Steam sterilization exposure times are measured from the moment the thermometer in the chamber (usually located in the discharge line) indicates the programmed temperature is reached. Temperature regulation is usually done by increasing or decreasing the steam pressure in the sterilizer chamber. As stated earlier, *steam temperature, not pressure, is the critical factor*. The pressure is used to regulate the temperature only, and the same pressure in one geographical location does not necessarily result in the same temperature as in another location.

To bring the steam temperature *at sea level* to 250° F (121° C) requires a gauge pressure of 15 to 17 pounds per square inch (psi). To reach 270° F requires a pressure of approximately 27 to 28 psi. At higher altitudes, it is necessary to use higher steam pressures to achieve the minimum temperatures required for sterilization. For instance, the hospital at the Air Force Academy in Colorado is about 7,100 feet above sea level. To attain a 250° F temperature, the steam pressure is increased to approximately 18 to 21 psi. You get a rough estimate of how much increase is needed by adding 0.5 psi in pressure for every 1,000 feet in elevation above sea level. However, though pressure is important, *never measure a sterilization period only by the pressure gauge reading*. Pressure inside the sterilizer chamber, indicated by the gauge, is not an accurate indicator of positive sterilization because poor air removal and other factors determine the actual steam pressure.

Packaging and loading items

Packaging of items and loading of the sterilizer has to be done in a manner to permit free access of steam to all areas and surfaces in the load. When you load a sterilizer, you should arrange packages and containers (basins, bowls, prep cups, medicine glasses, etc.) on their sides so air is not trapped in pockets. Do not place them upright or in a manner that allows them to hold water. If the condensation “pools” in the containers, the sterilized items will not dry and contamination occurs via “strike-through.” Instrument sets or pans that must be sterilized “flat” should have perforated or mesh bottoms so they do not hold water. Also, do not place basins, bowls, or cups upside-down; this traps air, so the insides of the containers do not reach sterilizing conditions.

The primary exception to this loading rule is rigid container systems; most should be sterilized flat. Follow the container manufacturer’s and the sterilizer manufacturer’s written guidelines when using these containers. The design of the container can influence the sterilization cycle used. For example, some rigid containers do not have perforated bottoms, so they may **not** be used in a gravity-displacement sterilizer because air cannot escape downward through the container and air pockets would result. Non-perforated bottoms also would collect and allow the water in the steam to pool.

Facilitating steam penetration

The steam must be able to penetrate every fiber of permeable items, and contact all surfaces of all items in a sterilizer load. All dirt, organic material, grease, or oil has to be removed from the surfaces of all items to be sterilized because the steam cannot penetrate. Hinges and ratchets of all instruments should be opened. This is one of the reasons that exposure times vary; the exposure time must allow complete steam penetration to all parts of the load. Some materials are penetrated more easily than others, so it is important to follow the manufacturer's recommendations for each item being sterilized. A common example of this is air-powered instruments which often must be subjected to longer exposure periods than metal instruments do. Many facilities post charts next to the sterilizers listing the specific exposure periods for each specialty item used in the facility.

Monitoring the sterilization cycle

The sterilization cycle must be monitored by close supervision of processes, constant monitoring of control devices, proper use of biological and chemical sterilization indicators, and proper documentation of each sterilization cycle. Qualified, fully trained personnel should inspect and maintain sterilizers regularly. Problems to look for include:

- Unsaturated (superheated) steam.
- Wet (over-saturated) steam.
- Incomplete air removal from the chamber.
- Automatic timer failure and other mechanical failures.

Steam sterilization is safe, relatively simple, and extremely effective — especially with modern sterilizer design and operating controls. However, you must realize that effective steam sterilization depends on the right combination of several factors, most of which you — the sterilizer operator — have direct control of. Despite all the "high-tech" improvements in sterilization equipment, effective sterilization still depends heavily on the skill, knowledge, and conscientiousness of the operator. Learn everything you can about the steam sterilizers you work with. Read the manufacturer's operating instructions and recommendations and strictly follow all local policies, procedures, and guidelines pertaining to in-hospital sterilization.

Advantages and disadvantages

Why is steam sterilization the most widely used method of sterilization? To answer this question, we need to look at some of the advantages and disadvantages of steam sterilization.

Advantages of steam sterilization:

- Steam sterilization is relatively easy and safe. It is also the most "sure-fire" method of in-house sterilization available. If an item is not damaged by heat and moisture, chances are it can be — and should be — steam sterilized.
- Steam sterilization is the fastest method. Steam penetrates many items quickly, carries considerable heat, and rapidly transfers the heat to the items being sterilized (via the process of condensation). As a result, microbes are killed faster than during dry-heat or chemical sterilization.
- Steam sterilization is the least expensive method. Steam can be generated in either in-house boilers or out of the hospital, then be piped in to the sterilization area. Steam generators are also available that will generate steam from water when piped-in steam is not available.
- Many items used in surgery, such as metal instruments, are safely sterilized by steam. Steam leaves no residue after the process. Even fabrics such as linen can be repeatedly sterilized with minimal damage, provided they are properly re-processed before each sterilization cycle.
- Most steam sterilizers have automatic, pre-set controls that make each type of sterilization cycle virtually "fool-proof." All the operator has to do is properly load the items in the

chamber, close the door, and press the button to start the cycle. The sterilizer conditions the chamber, "times" the exposure period, exhausts the steam from the chamber, and dries the load. The operator listens for a buzzer or other alarm, and then opens the door. Many steam sterilizers have "manual overrides" that allow the operator to sterilize items in emergency situations, even if electrical power is lost.

Disadvantages of steam sterilization:

- Heat and moisture damages or destroys some materials and equipment (such as laryngoscopes and bronchoscopes).
- If the items being sterilized are not prepared, packaged, and loaded properly, the steam may not penetrate and sterilize the item, or the item may not dry properly. Wet items are contaminated via "strike-through."
- Steam must penetrate or directly contact all surfaces of items being sterilized. The packaging must allow penetration of steam, but prevent penetration of microbes after the sterilization cycle.
- Steam does not easily penetrate some materials, such as oils, greases, and powders. It also does not penetrate some components of some equipment. Dirt and organic soilage also reduces the steam penetration. All items to be sterilized must be thoroughly clean and grease or oil free. Since steam does not penetrate all materials equally, the exposure period is not constant and has to be adjusted for individual items.
- The quality of the steam is difficult for the operator to monitor. If the steam is not pure, air pockets may form in, moisture may collect on, or solid particles may stain items being sterilized.

NOTE: Automatic cycles *do not* remove the need for close supervision and monitoring of each and every sterilization load; they simply reduce the likelihood of "human error" during the cycle.

These are the principles, basic conditions, and advantages versus disadvantages of steam sterilization. You now need to learn about some of the common types of steam sterilizers used in the OR and SPD.

219. Common types of steam sterilizers

A steam sterilizer is basically a pressure chamber or vessel with a door through which materials are loaded. It has valves to control the entry and exit of steam and air, and monitoring devices to allow the operator to observe conditions inside the chamber. It is designed to house items and allow steam under pressure to penetrate these items. The modern steam sterilizer is available in many sizes, ranging from small office sterilizers to large, room-sized sterilizers.

The pressure steam sterilizer chamber is essentially the same as a home pressure cooker but has refinements that increase its dependability, convenience, and safety. The chamber has a *double wall*; it may help you to think of it as a big metal box "nested" inside a slightly bigger metal box. There is a space between the walls of the two boxes that serves as a *jacket* for the pressurized steam before the steam actually enters the sterilization chamber.

We begin with two steam sterilizers in wide use: the gravity displacement sterilizer and the prevacuum sterilizer. Both use steam under pressure as the sterilant. The primary difference in each is the method used to remove air from the chamber so that steam can take its place. The lesson concludes with a discussion of two other steam sterilizers: the high-speed pressure sterilizer and the instrument washer-sterilizer.

Gravity displacement steam sterilizer

Figure 4–1 shows the basic design of a typical gravity displacement, sometimes called a downward displacement, steam sterilizer. After the door is closed and the button is pressed to start the cycle, the following events take place in the sterilizer as shown in the figure.

1. The steam enters the chamber through an inlet located in the center of the topmost back of the chamber.
2. The steam is forced upward and to both sides in the chamber by a baffle plate. Because the hot steam is heavier than the cool air, gravity causes the steam to compress the air to the bottom-front of the sterilization chamber.
3. As the air is forced downward, a drain valve opens. This allows the cooler air to escape through a screened drain outlet located in the bottom-front of the chamber.
4. As the air is displaced by the steam, the temperature in the chamber and drain increases, causing the chamber drain valve to close. Then the steam begins to build pressure in the chamber. This process is rapid when the sterilizer is empty. But when it is filled, air can get trapped in and around the packages. This causes cool air pockets to form in the load preventing the steam from contacting all portions of the contents, which, in turn, severely decreases the killing power of the steam.
5. As the pressure rises, the temperature increases. If loaded properly, the steam penetrates to the center of all packs and heats all items.
6. When the internal thermometer measures that the proper temperature is reached, the timing of the exposure period begins. The internal thermometer is usually located in the discharge line, just after the chamber drain strainer but before the control valve, because it is the coolest area of the chamber.
7. Most gravity displacement sterilizers operate at 15 to 17 psi and at a temperature of 250 to 254° F. The *minimum exposure period* to kill all organisms is 15 minutes at 250° F, but, because the steam can take some time to penetrate and heat all items, 30 minutes is the most common exposure time used. These operating parameters vary, depending upon the items being sterilized, the size of the load, and manufacturer's recommendations.

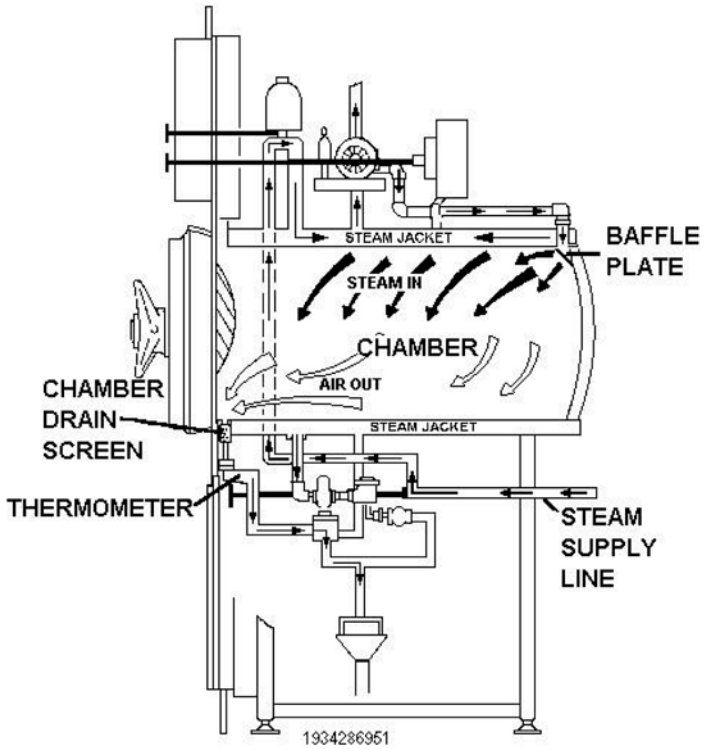

Figure 4–1. Cut away view of a typical gravity displacement sterilizer.

The exposure period is determined by considering three distinct phases: heat-up, thermal death (or holding), and a safety factor. A typical 30-minute cycle breaks down into three stages:

1. A 12-minute *heat-up period.* This allows the steam to penetrate the load and bring the temperature of all items in the load to the same temperature as the surrounding steam.
2. A 15-minute *thermal death period* or kill time. This is the *minimum* recommended time for a 250° F sterilizer load to ensure total destruction of all microorganisms.
3. A three-minute *safety factor.* This is generally added to each cycle to ensure that effective sterilization is achieved.

When the preset exposure time is reached, the steam is automatically and rapidly exhausted from the chamber and a drying cycle begins. The typical dry cycle in a gravity displacement sterilizer is 15 minutes. At the end of this "dry" cycle, the chamber pressure returns to zero, an audible alarm sounds, and the operator opens the door.

Note that the total cycle time, from the time you close the sterilizer door and push the cycle "start" button until the drying period is completed, is much longer than the sterilization time you preset on the sterilizer control panel. The entire cycle includes the time it takes to:

- Remove the air from and pressurize the chamber with steam.
- Sterilize the load.
- Exhaust the steam from the chamber.
- Dry the load.

Total cycle time averages about 60 minutes for a 30-minute *exposure period* cycle.

When the end-of-cycle signal sounds, open the door slightly, or *crack the door*. This allows residual steam to vent from the chamber. Allow a few minutes for the items in the sterilizer load to begin cooling-down in the chamber before removing them for final cooling and drying.

Prevacuum steam sterilizer

This sterilizer design provides a faster and more reliable method of sterilization than that provided by the gravity displacement sterilizer. As stated previously, air trapped inside the sterilizer chamber is one of the greatest dangers associated with steam-under-pressure sterilization. The prevacuum sterilizer reduces this danger and improves the speed and efficiency of the sterilizer by using a pump to literally "suck" the air out of the chamber. This creates a near-perfect vacuum before the steam is introduced into the chamber which allows for rapid air removal; thereby resulting in faster (virtually instantaneous) and more positive steam penetration of the entire load.

As you can see from figure 4–2, the prevacuum sterilizer looks very similar to the gravity displacement sterilizer. The steam inlet and chamber drain are usually located in the same places as in the gravity sterilizer. The difference is in the sterilization cycle.

After the door is closed and the button is pressed to start the cycle, the following events occur in a typical prevacuum sterilizer.

1. First, the chamber drain valve opens, and the vacuum pump removes nearly all the air in the chamber.
2. A steam injector preconditions the load contents and assists the vacuum pump with air removal. This generally takes about eight to 10 minutes.
3. Next, the drain valve closes, and the sterilizing steam is rapidly forced into the chamber.
4. The vacuum and preconditioning phase allow the sterilizing steam to penetrate the contents almost instantly. The rest of the sterilizing cycle is similar to that of the gravity displacement sterilizer. Following the pressure and temperature increases, the timed cycle begins when the selected temperature is reached. Steam is automatically exhausted from the chamber after the exposure period is complete.

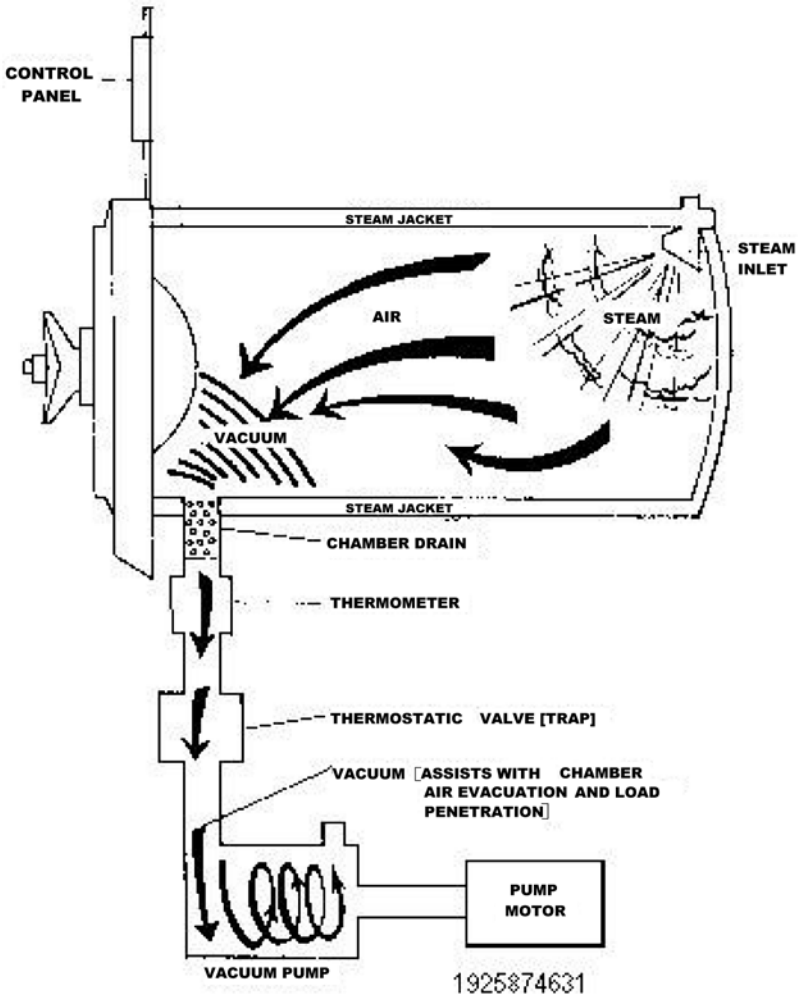

Figure 4–2. Cut away view of a typical prevacuum sterilizer.

After the sterilization cycle, a vacuum is again created to help moisture dissipate during the "dry" cycle.

The prevacuum sterilization cycle generally differs from the gravity displacement in three ways:

1. The sterilizer temperature is between 270 and 276° F.
2. The chamber pressure is set between 27 and 28 psi.
3. The exposure time period is a *minimum* of four minutes.

A typical prevacuum cycle takes between 15 and 30 minutes from start to finish, depending on factors such as sterilizer capacity, vacuum depth, and load contents.

Some prevacuum sterilizers use a series of vacuum *pulses* to evacuate the chamber. These pulses usually vary in depth with each pulse getting progressively stronger to ensure optimal evacuation of air during the conditioning phase and optimal evacuation of moisture during the drying phase. The total cycle time for these sterilizers is slightly longer than for single vacuum sterilizers.

High-speed pressure sterilizer (flash sterilizer)

This steam sterilizer is designed to sterilize small quantities of unwrapped surgical instruments or supplies that are needed quickly. It is generally used for instruments that have been omitted from sets or that have been accidentally contaminated during a surgical procedure. As the name (flash) implies, it is *designed for rapid sterilization*.

The flash sterilizer may operate as a gravity displacement sterilizer, a prevacuum sterilizer, or may be capable of both types of sterilization cycles. The most common flash cycle is a prevacuum cycle with a chamber pressure of 27 to 28 psi, a temperature between 270 and 274° F, and a *minimum exposure period* of three minutes. This cycle is only acceptable for small quantities of unwrapped, non-porous, non-lumen containing items. The time must be increased for other types of items.

NOTE: Items intended for implantation should *never be flash sterilized routinely*.

The specific uses and applications of flash sterilization are controversial, so flash sterilizers should be used only in special situations:

- When the preferred method of sterilization is impractical or not available.
- In ORs specifically designed to meet all national standards for flash sterilization and decontamination.

As always, follow the specific, written, policies established by your facility for flash sterilization procedures.

Instrument washer-sterilizer

This sterilizer is designed primarily for decontaminating and terminally sterilizing *used* patient care items. Because the washer-sterilizer uses the high temperatures associated with steam sterilization, all gross contaminants and visible organic debris should be removed from the instruments before they are processed in the washer-sterilizer. If a grossly contaminated item is processed, the debris is literally "baked-on" and is nearly impossible to remove. Many surgical instruments have been seriously damaged when a technician failed to clean the instruments during (and immediately after) the surgical procedure and the instruments were washer-sterilized.

The wash-and-sterilize cycle consists of two distinct parts. The *wash cycle* washes the instruments in a detergent solution. The method used to wash the instruments—and the effectiveness of the wash—depends on the sterilizer. Most washer-sterilizer chambers fill with water and use "jets" to agitate the water to clean the instruments. A few washer sterilizers use "spray-arms" to wash the instruments. After the contents are washed, they are usually rinsed with clean water, then the *sterilize phase* of the cycle begins. Most washer-sterilizers use a standard three- or 10-minute "flash" cycle at 270° F as the sterilize phase of the cycle. Because washer-sterilizer chambers are usually single-walled, there is not a steam jacket to provide residual heat. Therefore, there is usually *no* "dry" phase. When the sterilization phase is complete, the instruments are removed from the chamber for further processing. A washer-sterilizer cycle should be used *only for terminal sterilization*. *Do not* use items from the washer-sterilizer on a patient until the instruments are inspected for cleanliness and sterilized by a more "permanent" method.

In addition to the wash-sterilize cycle, most washer-sterilizers have other sterilization cycles programmed to increase their versatility. These cycles can generally be used only for unwrapped items because there is no drying phase. The cycles on most units are the:

- Three-minute "flash" cycle at 270° F for sterilizing unwrapped non-porous instruments or utensils.
- Ten-minute "flash" cycle at 270° F for sterilizing other unwrapped instruments, utensils, glass, tubing, or mixed loads of porous items.

Summary

This lesson briefly outlined the four major types of steam sterilizers commonly used in hospitals. It also covered the basics of how each one works. One item needs to be emphasized: *the operating parameters cited are only typical guidelines or minimum requirements*. Always follow local policy and the manufacturer's guidelines for the specific sterilizer used in your facility.

Now that you know the basics about steam sterilizers, the next lesson focuses on using them; particularly on the loading, unloading, and routine operator maintenance procedures.

220. Loading, unloading, and operator maintenance of steam sterilizers

As stated previously, to effectively sterilize using steam under pressure, the steam must thoroughly penetrate permeable items, and must contact all areas of all items being sterilized. To ensure this happens during a sterilization cycle, the sterilizer must be loaded properly.

Loading the sterilizer

To ensure steam sterilization is accomplished in an effective and reliable manner, there are several rules to follow when loading the sterilization chamber. Figure 4–3, A through D, shows some examples of properly loaded sterilizer carts. Refer to it as you study the "Do's and Don'ts" of sterilizer loading.

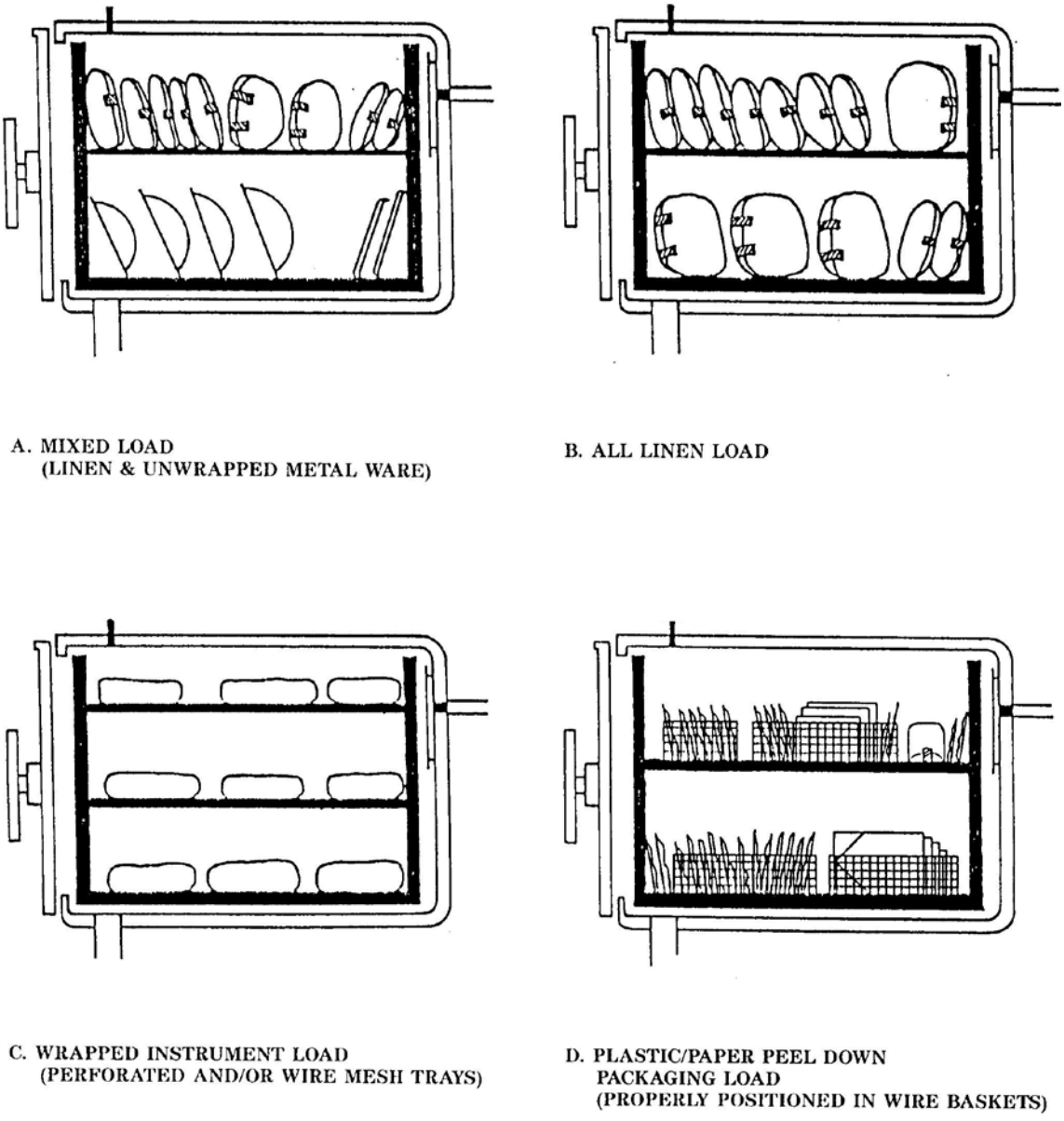

Figure 4–3. Various "mixed" sterilizer loads.

General Rules for Sterilizer Loading	
DO	Load all packages with loose contact between individual items.
DON'T	Overcrowd or overload the chamber racks or sterilizer cart.
This ensures the passage of steam meets minimal resistance from the top to the bottom of the chamber and throughout the load. By not overloading the sterilizer, you reduce the tendency for air pockets to form in the load and shorten load drying time.	
DO	• Place all packages, trays, and sets (except rigid containers) on edge with the longest side of the pack on the rack shelf. • Place receptacles such as basins and bowls on their sides. • Tip wrapped packages slightly forward (fig. 4–3, A). • Place rigid containers flat on the shelf. • Allow at least three inches between the top of the sterilizer chamber and the topmost packages of the load.
DON'T	Ever allow items in the load to touch the sterilizer chamber walls.
This prevents air pocket formation, ensures that steam freely contacts all surfaces, and prevents condensation from being trapped in containers during load cool down.	
DO	• Place hard goods on the bottom shelf; linens and soft goods on the top (fig. 4–3, A). • Place the larger packs on the lower shelves and the smaller packs on the top shelves. (fig. 4–3, B).
DON'T	Place instrument sets with numerous metal instruments directly over linen goods or porous, absorbent items.
This stops the linen packs and smaller items from getting wet from the water condensation in the hard goods and large packages as the load cools.	
DO	• Place heavy instrument sets in mesh or perforated bottom trays, flat on the rack or cart shelf (fig. 4–3, C). • Place rigid containers flat on the sterilizer shelf.
DON'T	• Ever place packages directly on the sterilizer chamber floor. • "Stack" rigid containers unless the container manufacturer and sterilizer manufacturer specifically state they may be stacked.
This allows adequate air removal and steam circulation. If heavy items are stacked together, the weight tends to compress the load and reduce the steam circulation.	
DO	• Place paper and plastic peel packaged items on edge with the plastic side of one package facing the paper side of the adjacent package. • Use wire baskets to hold the peel packaged items on the rack or cart shelves to ensure this position is maintained during the cycle and to provide easier handling (fig. 4–3, D).
DON'T	Place them together plastic-to-plastic, or lying flat on the shelf
The steam may not penetrate between the two layers of plastic to plastic, and moisture may collect in concave surfaces of peel-packs placed flat on the shelf.	
DO	Sterilize like items together in a load (whenever possible); do not mix with other type items. For example, sterilize linens in one load and hard goods (instrument sets, basins, trays) in a separate load.
Sterilizing like items together ensures that items that require the same exposure time, temperature, pressure, drying time, etc., are subjected to the proper requirements for sterilization and safe handling.	
DO	• Promptly check the chamber pressure gauge prior to opening the door once the sterilization cycle is finished and the audible alarm sounds. • Remove the sterilized load as soon as possible after any locally specified "cool-down" period.
DON'T	• Put items into a heated sterilizer until its time to start the sterilization cycle. • Leave items in a hot sterilizer for extended periods.
Permitting items to remain in the hot chamber causes the linen and other contents to over-dry or become superheated, and may cause permanent damage.	

After the sterilizer is loaded, the items are steam sterilized by one of the methods covered previously, and the "cycle complete" alarm sounds. You must now unload the sterilizer.

Unloading the sterilizer

As soon as the alarm sounds, check the chamber pressure gauge or digital readout to ensure there is no pressure in the chamber.

- Always check the chamber pressure *before opening any sterilizer door*.
- As you open the sterilizer door, stand slightly towards the hinged side, *never directly in front of the opening side of the chamber*.

These safety precautions greatly reduce the likelihood you will ever suffer a steam burn or other injury as you open the sterilizer door. All sterilizers have a pressure-lock system on the door that prevents it from being opened when steam pressure is still in the chamber. However, particularly with older sterilizers, this safety device may fail. You never know when a mechanical device will malfunction, so check the chamber pressure. And, just in case—keep the door between you and the heat!

The next step is to "crack" (open) the door slightly a few inches (about 6–8 inches) to allow the residual steam in the chamber to vent. Again, *do not* stand in front of the open door, you *can* get burned. Allow the load to cool-down for the period specified by your local policy, usually 15 to 30 minutes. This helps any remaining moisture to evaporate and makes the load slightly cooler and safer to transport to the sterile supply cooling area. It also reduces the likelihood of condensation occurring within the packs, which results if the hot items are exposed to cool room air too quickly.

After this cool-down period in the sterilizer, unload the items from the sterilizer. If the items are on a roll-out rack, unloading is greatly simplified. All you have to do is position the rack cart in front of the sterilizer, lock it in place, and roll the rack out of the chamber onto the cart until it locks into position on the cart frame. *Always wear heat-resistant, insulated gloves to cover your hands and forearms when pulling the rack onto the cart.*

The rack, chamber door, chamber walls, and load items are still extremely hot and can give you a severe contact burn. Place the rack and cart in an area free of cold drafts, and not directly under an air conditioning duct, to prevent the load from cooling too fast. If the hot load is cooled too rapidly, condensation forms in the packs resulting in strike-through contamination. Allow the load to cool to room temperature. This usually takes an hour or more, depending on contents of the load and the environment in the cool-down area. It's a good idea to advise other personnel who may need to enter the cool-down area that the load is hot. Some units place simple signs in front of hot items to keep others from receiving an unpleasant surprise!

When the load reaches room temperature, you can safely store or transport the items. Always check the outside wrappers of every item in the load for signs of wetness. If water droplets or visible moisture is on the outer wrapper or securing tape, the package is considered contaminated. If a number of items are wet, the entire load is usually considered contaminated. In this case, a mechanical sterilizer malfunction should be suspected.

Unloading items directly from a sterilizer shelf is *not* recommended, but is sometimes unavoidable. Follow the same basic guidelines when unloading individual items by hand. However, there are several additional precautions to take.

- Once again, always wear protective gloves when manually unloading individual items.
- Handle the items as little as possible—transfer them from the sterilizer directly to a drying rack or table if at all possible.
- Don't place the hot items on a cold surface. Put them on a well-padded, fabric covered surface to prevent condensation.

- Check for wet packs and allow the items to cool to room temperature in an area free from drafts and air conditioning currents before storing them.

Never allow sterilized items to remain in the sterilizer chamber for long periods of time following sterilization. Over-drying leads to linen deterioration, causes tape to bake onto the wrappers, can damage package contents, and potentially could cause a fire.

Routine operator maintenance of steam sterilizers

To ensure steam sterilizers stay in top working order, and to protect the taxpayer's investment in expensive equipment, you must perform some routine operator maintenance tasks. Clean and inspect steam sterilizers on a regular basis. Establish and strictly follow daily and weekly routines.

Sterilizer Cleaning & Inspecting Routines	
Daily	**Weekly**
Perform the procedures listed below the first thing in the morning when the sterilizer is cool. • Clean the interior of the chamber, the door, and all trays, carriages, and racks with a mild detergent; rinse with clean tap water. Never use strong abrasive cleaners, wire brushes, steel wool, or similar substances to clean the sterilizer as they damage the metal surfaces and lead to rusting and corrosion. Refer to the sterilizer manufacturer's instruction manual for recommended cleaning agents and procedures. • Remove the chamber drain strainer (plug screen) and use a brush to clean lint and sediment from the openings in the screen. This permits free discharge of air at the beginning of the sterilizing cycle and proper steam exhaust at the end of the cycle. Don't forget to replace the strainer after cleaning.	In addition to the daily maintenance routines, perform the following operator maintenance steps weekly. • Remove the chamber drain strainer or screen and clean the chamber discharge line and steam trap by flushing with a solution of trisodium phosphate and hot water, or other manufacturer recommended product. Mix one ounce of trisodium phosphate to one quart of water or use a non-phosphate detergent as a flushing agent (liquid detergents designed for use in the ultrasonic cleaner can usually be used as a substitute for trisodium phosphate). Follow this by flushing the drain with one quart of hot water. • Check the sterilizer controls for burned out indicator lights, faulty gauges, loose or leaking control valves, faulty thermometers, etc. • Check the door closing mechanisms. Also, check the door gasket for cleanliness, proper fit, and signs of deterioration. • Visually inspect steam and water lines for leaks. Do not touch them! Leave repair to the professionals.

If you discover any problems, immediately report them to your supervisor and then medical equipment maintenance personnel. *Do not use the sterilizer until it is repaired and tested according to local policies.*

Medical maintenance personnel also perform extensive periodic inspections and preventive maintenance in accordance with the manufacturer's recommendations. Work with them to ensure your steam sterilizing equipment stays in top shape.

Understanding and preventing steam sterilization errors

Despite all the built-in cycle controls and routine maintenance on steam sterilizers, errors in sterilization do occur. *The number one reason a non-sterile item gets used on a patient is that somebody made a mistake!* Most errors that cause sterilization failures originate with people.

As a professional, it is your duty and obligation to prevent harm to your patients, so you must be able to prevent, recognize, and correct sterilization errors. The major errors and prevention or correction measures are discussed in the following table:

Steam Sterilization Errors and Prevention/Correction Techniques	
Error	**Prevention/Correction**
Failure to observe and/or understand the sterilizer conditions required to maintain saturated steam at sterilizing temperature.	Monitor each cycle and follow all guidelines regarding sterilization parameters.
Using incorrect methods for packaging and wrapping supplies; failing to pay close attention to how individual items are packaged in sets or packs.	Since the presence of cool air pockets is not usually shown on the external gauges, it is essential that packaging be done properly.
Carelessly loading the sterilizer; overloading the sterilizer. This prevents complete air removal and free circulation of steam throughout the load.	Load the sterilizer in a manner that will allow all air to escape; otherwise, a mixture of air and steam will cause a lower temperature. Gauges and mechanical monitoring devices on the outside of the sterilizer cannot accurately indicate this error.
Failing to time the exposure period correctly.	You must know the time-temperature relationship needed to destroy the most resistant forms of microbial life and the time necessary for the steam to penetrate to the center of the densest package to assure thermal death. Again, refer to the manufacturer's operating instruction manual.
Attempting to sterilize materials that are impervious to steam, such as talcum powder or petrolatum.	Don't use steam to sterilize these materials.
Removing wrapped supplies from the sterilizer while they are damp.	• Supplies must be allowed to dry following sterilization and completion of the drying cycle. • If the supplies are damp when removed, droplets of moisture form and contamination is likely to result. • On the other hand, over-drying is likely to damage materials.
Attempting "shortcuts" to recommended methods of preparation and sterilization.	"Quittin' time" is no excuse for contamination! Don't take "shortcuts."
Equipment failure due to improper operator maintenance—a clogged drain screen is a prime example—or because the equipment has not been inspected regularly.	• Failure to follow directions of the manufacturer also contributes to these errors. • Because most OR and SPD personnel are not technically trained to repair or make adjustments to sterilizers, it is important that qualified maintenance personnel or manufacturer's representatives inspect and maintain sterilizers on a regular basis. (Assigned personnel perform routine, non-technical, operator maintenance.)

Despite the best maintenance efforts, mechanical failures can and do occur, resulting in sterilization failures. Often, these failures can be attributed to changes in the water and steam quality supplying the sterilizer. The minerals in the water and steam cause buildups of deposits in the numerous pipes, valves, fittings, and steam traps in the steam sterilizer that can eventually lead to malfunction. Opinions of operators or other experienced personnel should never be taken lightly. If you think "something doesn't seem quite right with this sterilizer," don't ignore your "hunch." Tell your supervisor or NCOIC — or would you rather infect a patient?

Summary

This section covered a lot of information on steam sterilization. It began by discussing the theory, principles, and required conditions for steam sterilization, then compared some of the advantages and disadvantages of steam sterilization. Next, the basic steam sterilizer designs and operation were looked at. The final lesson presented dos and don'ts for loading the sterilizer, followed by a summary of unloading procedures, and a listing of common sterilization errors and some ways to prevent those

errors. Answer the following questions to see if you've retained enough information to comfortably move on to our next subject: chemical sterilization.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

218. Theory, principles, and basic conditions for steam sterilization

1. How does moist heat provided by steam under pressure destroy microorganisms?

2. Define "saturated steam."

3. Which factor is of greater concern in steam sterilization: temperature or pressure? Why?

4. What is meant by the term "pure steam?"

5. What is the *maximum time* a living organism can survive when exposed to 250° F saturated steam?

6. What action must be taken at altitudes above sea level to maintain the minimum temperature of steam to ensure effective sterilization?

7. What type of rigid containers should *not* be used in a gravity displacement sterilizer? Why?

8. Why must all dirt, organic material, and oil be removed from the surfaces of items to be sterilized?

9. Why do exposure times vary during steam sterilization?

10. Briefly state four advantages of steam sterilization.

11. Why can't steam sterilization be used to sterilize materials and equipment such as laryngoscopes and bronchoscopes?

12. Name three types of materials not easily penetrated by steam.

13. Why is steam quality a disadvantage of steam sterilization?

219. Common types of steam sterilizers

1. How is air removed from the chamber of a downward displacement steam sterilizer during the sterilization cycle?

2. When does the sterilization timing actually begin during the operation of a downward displacement sterilizer?

3. What is the most common time exposure period for a gravity displacement sterilizer? Why?

4. What are the three phases of the sterilization cycle in a gravity displacement sterilizer?

5. How is the speed and efficiency of sterilization improved in a prevacuum, high-temperature sterilizer?

6. What steam temperature range is used in prevacuum, high-temperature sterilizers?

7. What type sterilization cycle is most commonly used in a flash sterilizer and what chamber pressure and temperature ranges are used in this cycle?

8. How long is the minimum exposure period for unwrapped instruments sterilized in a flash sterilizer?

9. What type of patient care items are never routinely sterilized in a flash sterilizer?

10. Describe the two different cycles of a typical washer-sterilizer.

220. Loading, unloading, and operator maintenance of steam sterilizers

1. Why do you load all packages with loose contact between individual items in a sterilizer load?

2. Describe how to position packages, trays, and sets on the sterilizer rack shelves.

3. Why are containers, such as bowls and basins, placed on their side and tipped forward when loaded into the sterilizer?

4. What is the *minimum distance* allowed between the top of the sterilizer chamber and the topmost packages of the load?

5. Describe the proper loading technique for paper-plastic peel packaged items.

6. What is the first thing you do after the cycle completion alarm sounds?

7. Where should you stand when opening a sterilizer door? Why?

8. Why do you “crack” the sterilizer door open a few inches and leave it that way for 15–30 minutes following the sterilization cycle?

9. What do you look for on the outside wrapper of items as you unload a steam sterilizer?

10. Cite two additional precautions you take when manually unloading individual items from a sterilizer chamber rack that is not necessary when unloading a load on a cart rack.

11. What two routine operator maintenance activities are accomplished daily for steam sterilizers?

12. How is the chamber discharge line of a steam sterilizer cleaned on a weekly basis?

13. What is the number one cause of sterilization errors?

14. When you carelessly load the sterilizer, or overload the chamber, what can happen that will result in a sterilization failure?

15. Who must perform technical inspections and maintenance on your steam sterilizers, and why is this important?

16. Name one factor that can cause steam sterilizer malfunction despite the best maintenance efforts.

4–3. Chemical Sterilization

As previously mentioned, chemical sterilization is another effective method of sterilizing heat sensitive instruments and supplies. Because many instruments can't withstand high temperature sterilization, chemical sterilization is an excellent means of sterilizing these products. In this unit we will discuss the use and operation of the peracetic acid sterilizer or processor. (In this lesson the words "sterilizer" and "processor" are used interchangeably). We will briefly discuss the theory behind this method of sterilization. Finally, we will discuss the loading, unloading, biological monitoring, and preventative maintenance of the peracetic acid sterilizer.

221. Use and operation of a peracetic acid sterilizer

Our discussion begins with a basic description of a peracetic acid sterilizer and the theory behind how peracetic acid sterilization works.

Description and theory of peracetic acid sterilization

A peracetic acid sterilizer, or processor, is a low temperature liquid immersion chemical sterilizer (fig. 4–4). Because it is low temperature, it allows you, the user, the flexibility to sterilize heat-sensitive and delicate instruments and devices. During sterilization, the surgical instruments and devices are completely submersed in a peracetic acid solution. It is extremely important that all items sterilized in this processor are submersible. (Always refer to manufacturer's recommendations before sterilizing a product.)

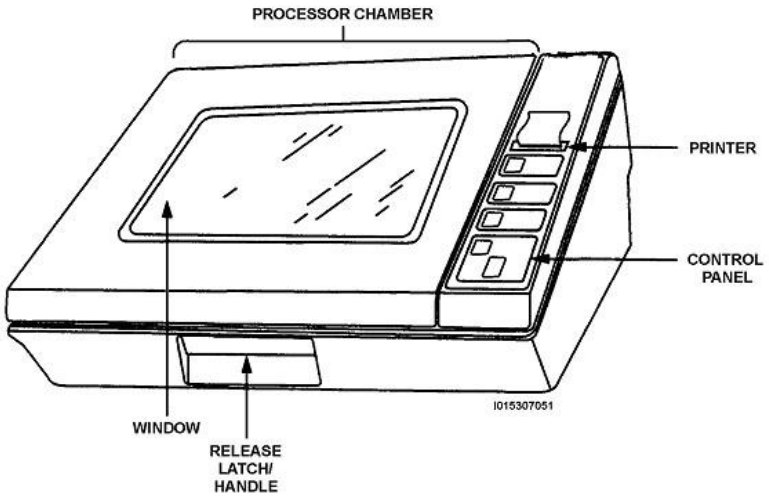

Figure 4–4. Front view of peracetic acid sterilizer/processor.

The most common type of peracetic sterilizer uses a formulation of 35 percent peracetic acid, hydrogen peroxide, and water. Most authorities believe that peracetic acid sterilization inactivates critical microbial cell systems. Peracetic acid is a combination of acetic acid and an extra oxygen atom. The combination of the acetic acid and oxygen atom react together with most cellular components to cause cell death. The sterilant is supplied in unit doses and is diluted to 0.2 percent peracetic acid solution during the sterilization process.

Operation of peracetic acid sterilizer

The peracetic acid processor is a fairly simple piece of equipment to operate. Once you prepare your instruments and devices for sterilization, place them in the processor, add sterilant, press the start button, and the processor does the rest. The processor submerses the instruments and devices in a 122 to 131° F (50 to 55° C) peracetic acid solution for 12 minutes. Once that is completed, it will perform four consecutive rinses with sterile water. At the completion of the cycle, an audible alarm will sound and the “cycle completion” light will come on. One of the unique qualities of the peracetic acid sterilizer is that it has a self-diagnostics monitor which continually monitors all conditions of the sterilization process. In the event of a malfunction, the sterilization processor automatically aborts the cycle and prints out the reason the cycle aborted. This is a real brief synopsis of what happens. Let’s take a look at the process in more detail.

First, let’s look at the peracetic acid processor (fig. 4–4). Notice there is a latch near the bottom in the middle of the processor. To open the processor, simply pull up on the latch and the lid will open. Once you open the lid to the processor, notice there is an empty chamber with a fill valve connection and a drain connection. Before sterilization, choose the appropriate processing tray to place in the chamber. There are two types: general processing tray and flexible processing tray.

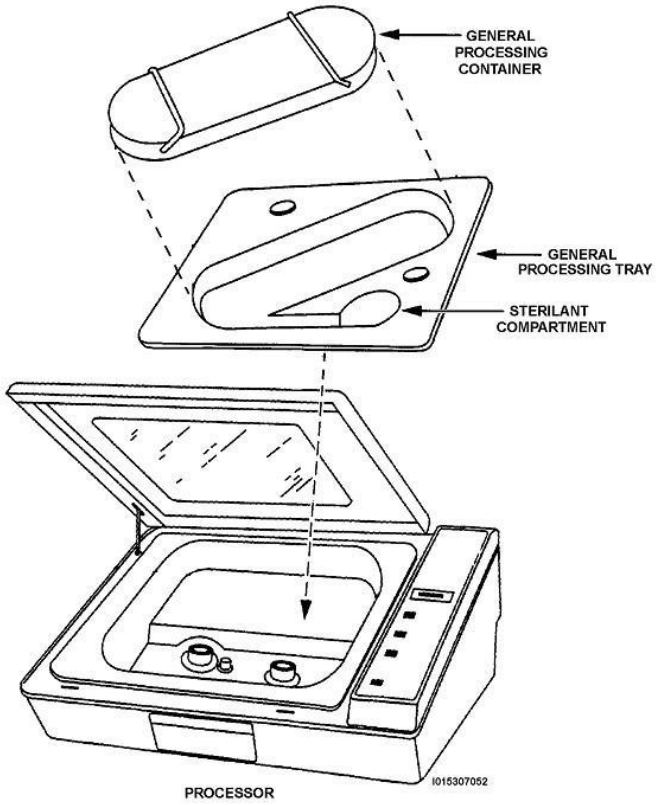

Figure 4–5. Open view of peracetic acid sterilizer/processor with general processing tray/container.

The first type of processing tray is a *general processing tray* (fig. 4–5). This tray is used to sterilize surgical instruments, cameras, light cords, adapters, and rigid endoscopic devices. The second type of processing tray is a *flexible processing tray* (fig. 4–6). This tray has a special design that allows you to place a flexible endoscope into the tray without kinking it. *Always remember how delicate flexible endoscopes are.* It also has special connectors and tubing to introduce the sterilant into the endoscope lumen to ensure complete sterilization.

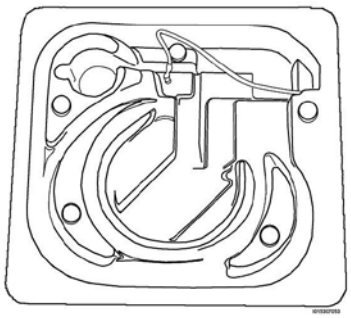

Figure 4–6. Top view of flexible processing tray for use with peracetic acid sterilizer/processor.

Once you determine the type of processing tray you need, place it inside the processor chamber. If you are using the flexible processing tray, place your scope directly into the processing tray and connect the special tubing and connectors. (Refer to the manufacturer's recommendations when selecting and connecting different types of hoses and connectors.) If you are sterilizing instruments, cameras, light cords, adapters, or rigid endoscopic devices, place them in a general processing container with a chemical indicator and then place the container inside the processing tray. We will discuss loading instruments into the processing container later in this unit.

Once you load your instruments or devices into the processor, place the sterilant into the processor. Before you place the sterilant into the sterilizer, verify the expiration date, ensure the container is intact, and gently squeeze the bottom of the container to make sure the powder is soft. Next, place the container into the bottom right-hand side of the processing tray. Push the sterilant container down until the lid is flush with the processing tray. Once you start pushing it down, a cup cutter in the bottom of the processor will cause a slight clockwise rotation as it tears a hole in the bottom of the container and releases the buffer powder into the processor. The next step is to insert the plastic aspirator probe assembly into the center of the lid of the sterilant container until it is firmly seated on the container. *Make sure the plastic hose connected to the aspirator probe is not kinked.* This allows the sterilant to flow freely during the sterilization process. Then, close the lid and press the start button. If you meet resistance when closing the lid, stop and inspect the positioning of the container, tray, and aspirator assembly. From this moment on, the process is automated so all you need to do is wait for the process to finish.

Once you press the start button, the chamber begins to fill with water and peracetic acid sterilant. As it dilutes, it will turn to a greenish-yellow color. All devices in the processor are submerged in the heated sterilant. During the sterilization process, the peracetic acid solution is heated to a temperature between 122 and 131° F (50 and 55° C) for a 12-minute period.Once the sterilization cycle is completed, the sterilant is discharged through a sanitary drain. The instruments are then automatically rinsed in tap water a total of four times. The peracetic acid sterilizer has a filtering system where tap water is filtered through two external prefilters in addition to an internal micro filtration system. Even the smallest known bacterium, Pseudomonas diminuta, is unable to pass through this filter system. After the fourth rinse, the cycle is completed. An audible alarm will sound and the "cycle completion" light will come on. The entire process takes 20 to 30 minutes. The actual processing time is dependent upon water temperature, water pressure, and the status of the water filter. When the cycle is complete; press the "cancel" button. Once this is accomplished, the inflatable seal will deflate. Then, lift the handle and open the lid. Check the chemical indicator and the processor printout to ensure all sterilization parameters were met. The product is now sterile and ready for immediate use. Finally, remove the aspirator probe from the sterilant container, remove the empty sterilant container, and discard it in the trash.

Advantages and disadvantages

Now let's turn our attention to some of the advantages and disadvantages of peracetic acid sterilization.

Advantages of peracetic acid sterilization:

- Peracetic acid sterilization is relatively easy and safe. It is a fairly fast method of sterilizing medical instruments and devices.
- Many heat-sensitive items used in surgery, such as scopes and cameras, are safely sterilized with peracetic acid.
- The peracetic acid sterilizer has a self-diagnostics monitor that continually monitors all conditions of the sterilization process. In the event of a malfunction, the processor automatically aborts the cycle and prints out the reason the cycle aborted.
- It uses a standard tap water supply, a regular sanitary drain, and a standard 110-volt electrical connection.
- During the sterilization process, the processing tray is also sterilized. It can be directly transferred to the sterile field using aseptic technique.
- All the operator has to do is properly load the items in the processor, place the sterilant in the appropriate location, close the door, and press the start button. The processor takes over from there. Once you hear the audible alarm, open the sterilizer and remove the sterile processing tray.

Disadvantages of peracetic acid sterilization:

- Peracetic acid must penetrate or directly contact all surfaces of items being sterilized.
- In order for peracetic acid to effectively sterilize, all items must be thoroughly clean and free of grease and oil.
- Cannot be used for long-term storage. This process is designed for “just-in-time” sterilization.
- You cannot sterilize items that cannot be submersed in liquid.
- You must avoid contact with the skin because peracetic acid is corrosive and may cause skin irritation.

Loading, unloading, biological monitoring, and operator maintenance

As stated previously, to effectively sterilize using peracetic acid, the sterilant must thoroughly contact all areas of the items being sterilized. To make sure this happens during a sterilization cycle, the instrument and devices must be loaded properly.

Loading the sterilizer

To make sure sterilization is effective and reliable, follow these steps when loading instruments into the processing container:

1. The items must be properly cleaned prior to sterilization.
2. Ensure all devices are properly inspected and are in good working order.
3. Place water-resistant caps on cameras, light cables, etc., if required by the manufacturer’s recommendations. Failure to place caps on these devices may result in damage and costly repairs.
4. Position devices to ensure exposure of the sterilant to all surfaces. Make sure all devices are disassembled into the smallest components. Open all valves. All small components need to be placed in a mesh bag. Open the ratchets on all graspers and clamps.
5. Load the instruments into the processing container so as to allow gravity flow of the sterilant. Devices with lumens need to be positioned so as to allow the liquid sterilant to flow upward through the lumen. This also aids in proper rinsing of the device following sterilization.
6. Correctly place a chemical indicator in the processing container for *each* sterilization load.
7. Place the lid on top of the processing container and position it in the processing tray. Make sure you align the fluid ports of the processing container with the fluid ports of the processing

tray. You do this by resting the processing container on the rubber fluid port gasket. Now you are ready to close the lid and start the process.

If you are sterilizing flexible endoscopic equipment, you must carefully position the endoscope and accessories in the flexible processing tray. You must also attach appropriate adapters and hoses for proper sterilization. (Refer to the manufacturer's recommendations for positioning and proper attachments.)

Unloading the sterilizer

When the cycle is complete, an audible alarm will sound. Check the processor printout to ensure all conditions for sterilization were met. The following conditions must be reflected on the printout:

- Temperature reading should read between 122 and 131° F (50 and 55° C).
- The concentration must be 175 or greater.
- The exposure time must be 12 minutes.

Once you determine the conditions of sterilization were met, it is time to open the processor. The first step is to press the "cancel" button. Once you do this, the inflatable seal will deflate. Then lift the handle, open the lid and visually check the chemical indicator. The effectiveness of the chemical indicator is identified by a color change from white to purple. If the appropriate color change occurred, your product is now sterile and ready for immediate use. Finally, remove the aspirator probe from the sterilant container, remove the empty sterilant container, and discard the container in the trash.

One of the unique qualities is that this sterilization system sterilizes everything inside the processor—instruments and devices, processing container, and processing tray. The next step is to remove the processing container using aseptic technique. The entire container can be placed directly on to the sterile field.

Biological monitoring of the peracetic acid sterilizer

The peracetic acid sterilizer is unique in that it provides operators with three methods of quality assurance. First, it has a computer processor that monitors the entire sterilization process and identifies any problems. At the conclusion of a load, it prints a report that records the conditions of the sterilization process. Second, a chemical strip is placed in every load. The third and final quality assurance mechanism put into place to further monitor the effectiveness of the sterilization process is biological monitoring.

Biological monitoring ensures that sterilization conditions are met and maintained during the sterilization process. The biological indicator used to monitor the effectiveness of peracetic acid sterilization is either Bacillus subtilis or Bacillus stearothermophilus spore strips. Biological testing should be conducted and documented at least weekly. Refer to local policy for specific guidance on frequency.

To perform biological monitoring, take the following steps:

1. Put on a pair of gloves and open the envelope containing the spore strip. Using the special clip provided, grasp the spore strip and place it in the processing tray channel or in an empty processing container.
2. Add sterilant and run a standard sterilization cycle.
3. Once the cycle is complete, don new gloves. Using strict aseptic technique, transfer the spore strip into the biological vial. **Avoid contact with any unsterile surface!** Be careful not to let the indicator touch the outside of the vial because this can cause a false positive reading.
4. Once the spore strip is inserted into the vial, screw the cap on and make sure the spore strip is completely immersed.

5. Label the vial with the load number, the date, and your initials, and place it into the incubator. If you are using Bacillus subtilis spore strips, the incubator must be maintained at 37° C. If you are using Bacillus stearothermophilus, the incubator must be maintained at 56° C.
6. Annotate the appropriate information into the peracetic acid biological logbook.
7. The vial can be kept in the incubator up to seven days. Check for daily growth. Refer to local policy and/or manufacturer recommendations for completion of biological monitoring procedures.
8. In addition to placing the processed spore strip into the incubator, you also need to incubate a control. Remove a spore strip from its envelope and place it directly into the vial and incubate. Refer to local policy and/or manufacturer's recommendations for completion of biological monitoring procedures.

Routine operator maintenance of peracetic acid sterilizers

To ensure peracetic acid sterilizers stay in top working order, you must perform some routine operator maintenance tasks and checks. Clean and inspect sterilizers on a regular basis. Below is a list of the daily cleaning requirements for the peracetic acid sterilizer.

1. It is recommended that a diagnostic test be run on the peracetic acid sterilizer every 24 hours. Initiating a diagnostic test each day validates the integrity of the processor. The diagnostic test ensures all electro/mechanical systems and the sterile water filter are functioning correctly. The completion of a successful diagnostic cycle assures the user that the processor will operate appropriately. If a diagnostic cycle fails, the processor will prohibit you from initiating any cycles till the problem has been corrected and a successful diagnostic test has been completed. Refer to the manufacturer's manual on specific instructions for running a diagnostics cycle.
2. All cleaning of the processor should be done with a soft cloth dampened with 70 percent isopropyl alcohol. Clean the external surfaces of the processor first.
3. Open the lid and clean the processing tray by thoroughly wiping the inner surface and seal. Next, clean the processing container and accessories rack.
4. Wipe the aspirator assembly and sterilant compartment.
5. Visually inspect the aspirator assembly and make sure that the probe lumen is clear, that there are no cracks or chips, and that the hose connection is secure. If there is a crack or chip, replace the aspirator assembly.
6. Check the drain screen, which is located in the bottom of the sterilant compartment. Ensure it is clean and remove any lint or debris. To remove the screen, lift the processing tray and unscrew the drogue. Remember to replace the screen after cleaning.
7. Remove the processing tray and clean the processor chamber. Then replace the processing tray and container.
8. Open the control panel and check your printer paper. Replace with a new roll, as needed.

Since the peracetic acid sterilizer utilizes several filters, you will also be required to change these filters at their recommended time. Refer to the owner's manual for specific periodic maintenance schedule and instructions.

222. Use and operation of the hydrogen peroxide sterilizer

In our last lesson we looked at peracetic acid sterilization. Now we will take a look at another type of chemical sterilizer, the hydrogen peroxide sterilizer. Earlier in this unit, we talked about three types of hydrogen peroxide sterilizers—the plasma sterilizer, the gas plasma sterilizer, and the hydrogen peroxide sterilizer. Since the most common type you will see is the hydrogen peroxide plasma sterilizer, we will cover that in this lesson. Air Force SPD areas have moved away from the use of Ethylene Oxide sterilizers and replaced them with hydrogen peroxide sterilizers, so it is important to

have a general understanding of this sterilizer. Because the technology of hydrogen peroxide plasma sterilization is still new, this section is written from very limited resource materials. To get a more comprehensive understanding of this process, refer to your owner's manual.

Description and theory of hydrogen peroxide plasma sterilization

A hydrogen peroxide plasma sterilizer is a low temperature sterilizer that inactivates microorganisms on a wide range of medical and surgical devices and instruments (fig. 4–7). This sterilizer is safe, fast, effective, economical, and easy to use. It is also an extremely reliable and flexible sterilizer. The complete sterilization process takes from 54 to 74 minutes depending on exactly which model you have.

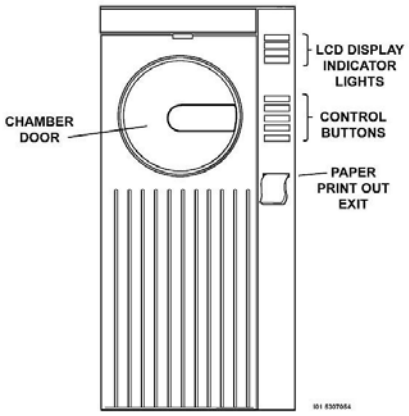

Figure 4–7. Typical front view of hydrogen *peroxide plasma sterilizer.*

In this sterilizer, the hydrogen peroxide creates reactive plasma when it is activated. This is done with the use of radio frequency energy. During the process, air is removed from the chamber and hydrogen peroxide is introduced and vaporized. Once the cloud of vapor is created, it consists of ions, electrons, and neutral atomic particles that produce a visible glow. The hydrogen peroxide plasma interacts with cell membranes, enzymes, and nucleic acids to disrupt the life functions of the microorganisms. The sterilizer maintains a temperature of 104° F (40 °C).

Operation of hydrogen peroxide plasma sterilizer

Just like the peracetic acid sterilizer, the hydrogen peroxide plasma sterilizer is also a fairly simple piece of equipment to operate. During the sterilization process, the hydrogen peroxide plasma sterilizer automatically monitors and controls the sterilization process. Most hydrogen peroxide plasma sterilizers use four different methods to do this:

1. **Message screen (LCD).** The screen continually indicates the status of the unit and displays the time remaining to cycle completion.
2. **Status indicator lights**. The lights identify the current stage of the sterilization cycle and assist you in monitoring the cycle stages (vacuum, injection, diffusion, plasma, and vent).
3. **Paper printout.** At the completion of a sterilization cycle or a cycle cancellation, a paper exits the front panel. This records the cycle parameters and should be kept for your records. If problems were encountered during the sterilization cycle, they will be identified on the printout.
4. **Beeps.** At the conclusion of a cycle or if a cancellation occurs, the beeps will alert you.

Once you prepare your instruments and devices, properly load them into the sterilizer chamber. Next, verify the status of the hydrogen peroxide plasma cassette. Most hydrogen peroxide cassettes provide enough hydrogen peroxide for several loads. If a cassette is empty or expired, it needs to be replaced. It also needs to be replaced if you are directed by a message on the sterilizer display. Once this is done, you are ready to start the cycle. Press the start button, and the processor does the rest. Once the cycle starts, there are five different stages the sterilizer goes through: vacuum, injection, diffusion, plasma, and vent. Depending on which sterilizer you use, it may go through just the five stages or it may go through the injection, diffusion, and plasma stage twice. The load is sterilized in approximately one hour. Once the load is completed, an audible alarm will sound and a message will be displayed on the message screen. A report will also print that records the conditions of the sterilization load. Once the cycle is complete, you can open the door. After you open the door, check your chemical strips and make sure they changed from red to yellow. Remember, the chemical

indicator doesn't guarantee sterility: it indicates the load was exposed to hydrogen peroxide. Remove the items from the chamber and they are ready for immediate use.

Advantages and disadvantages

Let's look at some of the advantages and disadvantages of hydrogen peroxide plasma sterilization.

Advantages of hydrogen peroxide plasma sterilization:

- The hydrogen peroxide plasma sterilization is dry and nontoxic.
- Because hydrogen peroxide plasma is a by-product of oxygen and water vapor, it can be evacuated into the room atmosphere.
- Its low temperature allows sterilization of many heat-sensitive items such as endoscopes and fiberoptic devices.
- The sterilizer is simple to operate and connects to a standard electrical outlet.
- It is safe, effective, economical, and easy to use.
- No aeration is required and the sterilized items are ready for immediate use.

Disadvantages of hydrogen peroxide plasma sterilization

- Metal trays block the radio-frequency waves.
- You cannot sterilize items with cellulose (i.e., woven textiles with cotton fibers and paper products).
- After repeated exposure, nylon becomes brittle.
- The concentrated hydrogen peroxide solution is corrosive to the skin, eyes, nose, throat, lungs, and gastrointestinal tract.
- All items must be cleaned and dried before sterilization. If the sterilizer detects moisture, it may cancel the cycle.
- The sterilizer cannot be unplugged or turned off for more than 24 hours.

Loading the hydrogen peroxide plasma sterilizer

To ensure sterilization is effective and reliable, follow these rules when loading instruments into the hydrogen peroxide plasma sterilizer:

1. Make sure that the items you are preparing for sterilization can be sterilized using hydrogen peroxide plasma. (The best way to determine if they are suitable for this type of sterilization is to refer to the medical device manufacturer's manual.) Hydrogen peroxide plasma is designed for sterilization of both metal and nonmetal devices. It is also suitable for heat and moisture sensitive instruments. *Do not* sterilize items with cellulose, such as woven textiles with cotton fibers and paper products or items that absorb liquids (i.e., gauze sponges, hand towels, linens). This means you cannot include count sheets inside your sets. *If an item is labeled for "gravity steam methods," or cannot withstand a vacuum, it cannot be sterilized in this sterilizer*.
2. All items placed in a hydrogen peroxide plasma sterilizer must be cleaned, rinsed, and dried. *Absolutely all moisture must be removed*.
3. Hydrogen peroxide plasma sterilizers require the use of special trays specifically designed to allow the diffusion of hydrogen peroxide and the plasma around all the items in the sterilizer. Do not pad trays with linen. Refer to manufacturer's recommendation for appropriate padding.
4. Arrange items in an instrument tray in a manner that allows the hydrogen peroxide and plasma to surround them. Do not stack instrument trays. Place a chemical indicator in each tray and peel pack.

5. When loading items into the sterilization chamber, place the trays flat on the shelves. *Do not stack trays or basins within the trays***.**
6. Position peel pouches on edge and arrange them so that the transparent side of the pouch faces the opaque side of the next pouch.
7. Do not allow any items to touch the walls or doors and provide at least one inch of space between the ceiling of the electrode and the top of the load.
8. Place a biological test pack in the sterilizer at the back of the sterilization chamber on the bottom shelf.

Unloading the sterilizer

Once the load is completed, an audible alarm will sound and a message will be displayed on the message screen. It will also print out a report that records the conditions of the sterilization load. Check the printout to make sure there were no problems with the load. Once the cycle is complete, you can open the door. After you open the door, check your chemical strips and make sure they changed from red to yellow. Remember, the chemical indicator doesn't guarantee sterility; it indicates the load was exposed to hydrogen peroxide. The items can be immediately removed from the sterilizer and delivered to their appropriate location.

Biological monitoring of the hydrogen peroxide plasma sterilizer

Biological monitoring ensures that sterilization conditions are met and maintained during the sterilization process. The biological indicator used to monitor the effectiveness of hydrogen peroxide plasma sterilization is *Bacillus subtilis* var. *niger* spore strips. Biological testing of hydrogen peroxide plasma sterilizers is accomplished through the use of commercially prepared test packs. The pack contains both a chemical and a biological indicator. Biological testing should be conducted and documented at least once per day. The correct placement of the biological indicator is at the back of the sterilization chamber, on the bottom shelf. Make sure the opening of the biological test pack is facing the back of the chamber and is not obstructed.

Once the sterilization load is completed, remove the test pack from the sterilizer. Check the chemical indicator for appropriate color change. If the appropriate color change is noted, remove the spore strip and transfer it into the vial using strict aseptic technique and incubate. *The transfer process should be completed within 15 minutes of cycle completion*. Refer to local policy and/or manufacturer's recommendations for completion of biological monitoring procedures**.**

Routine operator maintenance of hydrogen peroxide plasma sterilizers

To ensure hydrogen peroxide sterilizers stay in top working order, you must perform some routine operator maintenance tasks and checks. Clean and inspect sterilizers on a regular basis.

To clean the outside surfaces of the sterilizer, wipe them down with a mild detergent. The inside of the chamber normally doesn't require cleaning. Never wipe the chamber door or the chamber with anything abrasive. Refer to your manufacture's manual for specific cleaning requirements for your sterilizer.

Since the hydrogen peroxide plasma sterilizer uses hydrogen peroxide cassettes, you will need to replace the cassette collection box from time to time. The cassette collection box usually holds about 30 used cassettes. Other routine maintenance you will need to do is to replace the printer ribbon or cartridge, replace printer paper, and clean or replace the injector valve vaporizer bowl. Refer to the manufacturer's recommendations on the instructions to perform these tasks.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

221. Use and operation of a peracetic acid sterilizer

1. How does peracetic acid sterilization destroy microorganisms?

2. To what percentage is peracetic acid solution diluted during the sterilization process?

3. What happens if the self-diagnostic monitor detects a malfunction in the peracetic acid sterilizer?

4. What type of processing tray is used to sterilize surgical instruments, cameras, light cords, adapters, and rigid endoscopic devices in the peracetic acid sterilizer?

5. If you are using the flexible processing tray, how do you determine what type of tubing and connectors to use?

6. What three things must you do before you place the sterilant into the peracetic acid sterilizer?

7. Once you insert the plastic aspirator probe assembly into the center of the lid of the peracetic acid sterilant container, what critical step should you take to allow the sterilant to flow freely during the sterilization process?

8. To what temperature is the peracetic acid solution heated during the sterilization process? How long must items be exposed to the chemical sterilant?

9. How is tap water sterilized during the peracetic acid sterilization cycle?

10. What specific type of items cannot be sterilized using peracetic acid sterilization?

11. Why is it important to place water resistant caps on cameras and light cables if required by the manufacturer?

12. How do you load instruments into the processing container in a manner which allows gravity flow of the peracetic acid sterilant?

13. How often should a chemical indicator be run in a peracetic acid sterilizer?

14. What concentration of chemical sterilant should be reached to ensure effective sterilization in a peracetic acid sterilizer?

15. Once you determine the conditions of sterilization are met, what is the first step you take to open the peracetic acid sterilizer, and what happens when you perform this step?

16. Which items are considered sterile after the completion of a peracetic acid sterilization process?

17. What two types of biological indicator are used to monitor the effectiveness of peracetic acid sterilization?

18. When transferring the spore strip into the biological vial, what must you be careful to avoid?

19. If you are using Bacillus stearothermophilus spore strips, at what temperature must the incubator be maintained?

20. How often should a diagnostic test be run on the peracetic acid sterilizer?

21. What is the purpose of the diagnostic test on the peracetic acid sterilizer?

22. What happens if a diagnostic cycle fails?

23. What should you use to clean the peracetic acid sterilizer?

24. What should you do if you notice a crack or chips in the aspirator assembly of the peracetic acid sterilizer?

222. Use and operation of the hydrogen peroxide sterilizer

1. How does hydrogen peroxide sterilization destroy microorganisms?

2. What four methods does the hydrogen peroxide plasma sterilizer use to monitor the sterilization process?

3. What are the five different stages the hydrogen peroxide plasma sterilizer goes through during a sterilization load?

4. Approximately how long does it take for a hydrogen peroxide plasma load to run through a complete cycle?

5. What color change occurs on the chemical strip when an item is exposed to hydrogen peroxide?

6. Why can’t you use metal trays in a hydrogen peroxide plasma sterilizer?

7. Why must all items be thoroughly dried before you place them in a hydrogen peroxide plasma sterilizer?

8. What type of items should never be sterilized in a hydrogen peroxide plasma sterilizer?

9. How should items be packaged in the instrument tray prior to sterilization in the hydrogen peroxide plasma sterilizer?

10. How should trays be placed in the sterilization chamber of a hydrogen peroxide plasma sterilizer?

11. How should peel pouches be positioned in the sterilization chamber of a hydrogen peroxide plasma sterilizer?

12. Which type of biological indicator is used to monitor the effectiveness of hydrogen peroxide plasma sterilization? How often should you perform this test?

13. Where do you place the biological indicator in the hydrogen peroxide plasma sterilizer?

14. Within what time frame should the spore strip be transferred into the vial for incubation following the completion of the hydrogen peroxide plasma sterilization cycle?

15. How do you clean the outside surfaces of the hydrogen peroxide plasma sterilizer?

Answers to Self-Test Questions

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1. A process that destroys all living microorganisms, including bacterial spores and viruses.
2. When exposed to a sterilization process and all mechanical parameters are met and all external and internal sterilization cycle indicators are acceptable.
3. (1) High-level disinfection kills all microorganisms except spore-forming bacteria; the process may also kill spores if the exposure time is long enough and certain other conditions are met.
   (2) Intermediate-level disinfection kills most microorganisms, including bacteria, viruses, and fungi, but spores are not affected.
   (3) Low-level disinfection attacks vegetative bacteria, fungi, and the least-resistant viruses.
4. (1) To prevent microbes from being introduced into the patient where they can cause a surgical wound infection.
   (2) To achieve decontamination and render items used in surgical procedures safe for handling by hospital personnel. This helps prevent the spread of potentially pathogenic microorganisms to other patients, surgical personnel, and environmental surfaces.
5. Semicritical items.
6. They should be at least high-level disinfected.

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1. Moist heat, in the form of steam under pressure.
2. The steam (sterilant) is unable to penetrate them.
3. Steam under pressure.
4. Large, bulk loads of prepackaged, disposable supply items produced by commercial medical supply manufacturers.
5. The process is non-toxic and it sterilizes at cool temperatures; it also leaves no toxic residue, is dry, and the sterilizer is self sufficient.
6. Many items cannot be sterilized by this method, and special containers must be used.
7. (1) It is relatively fast when compared to most other cold-sterilization methods.
   (2) Almost any type of immersible surgical instrument can be processed.
   (3) The cycle is almost entirely automatic, minimizing the chances of human error.
   (4) The sterilant is single-use, so there is no possibility of cross-contamination.

(5) The solution discharged at cycle completion is not considered hazardous even by the strictest current laws.

8. 10 hours.

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1. The number and types of microorganisms (particularly their resistance) determine the effectiveness of a chemical agent. The greater the number and the more resistant the type of microbes, the less effective the disinfecting agent is.
2. Disinfectants vary in their level of effectiveness according to the makeup, or concentration of, the chemical agent and the manner in which it is used. If the concentration is diluted, the effectiveness decreases; an agent that is wiped on and allowed to dry is not as effective as the agent would be if the item were completely immersed for an extended period.
3. Cleaning, because the active ingredient of certain agents is inactivated by body proteins, levels of pH, or residual soaps.
4. Vegetative bacteria.
5. The more microorganisms present, the longer it takes the disinfectant to destroy them, and the more likely greater numbers of more resistant microbes are present.
6. The added moisture dilutes the concentration of the disinfectant, reducing its germicidal action, and moisture drops often contain air bubbles that can prevent the concentrated agent from reaching all areas of the surface.
7. The longer an item is exposed to the disinfecting agent, the more microbes are killed. Therefore, all agents are more effective as exposure time is increased.
8. Normally, the higher the temperature, the faster a germicide reacts (and destroys microbes) because the heat of the solution speeds up the chemical reactions that destroy the cells.
9. Plastic containers are used to contain disinfectants because many chemical disinfectants corrode metal surfaces.
10. Disassemble, if possible, the articles to be disinfected to allow disinfectant to contact all surfaces.
11. They need to be flushed with the disinfectant solution using a syringe.
12. As soon as the instrument is submerged and all surfaces are in contact with the disinfectant.
13. Sterile water.

217

1. *Staphylococcus aureus, Salmonella choleraesuis*, and *Pseudomonas aeruginosa*.
2. Because the Hepatitis B virus survives exposures to many disinfectants.
3. Is effective against a wide variety of microorganisms. It kills or irreversibly inactivates all vegetative bacteria, fungi, and viruses.
4. 10 minutes.
5. 15 minutes.
6. Because it dissolves the cement holding the lens in place.
7. Iodophor.
8. The solution is rendered non-toxic, non-staining, and non-irritating (unless the individual exposed to it is allergic to iodine); detergent also increases the biocidal activity of the iodine.
9. Phenolics.
10. (a) Glutaraldehyde is noncorrosive to lensed instruments and is safe for use on most rubber and plastic items. Some glutaraldehyde solutions also remain effective for extended periods, and can be reused if kept in closed containers. This agent remains effective in hard water, is easy to use, contains a rust inhibitor, and acts very rapidly.

    (b) Contact with the solution can irritate or burn the skin, eyes, and mucous membranes. Gloves and face protection must be worn. The fumes also irritate the eyes and respiratory tract; items exposed to glutaraldehyde must be thoroughly rinsed with sterile water before use to prevent tissue irritation or burns. Glutaraldehyde solutions are also absorbed by some materials, particularly woven polyesters.

218

1. By denaturation, a process whereby heat energy disrupts the structure of the cell and coagulates its protein, destroying the reproducing and life-sustaining activities of the cell.
2. Steam that contains a maximum amount of water vapor. It condenses into water when it contacts a cool object, releasing a large amount of heat.
3. Temperature is the major concern because it is the heat that kills the microbial cells, not pressure. Pressure is used only to raise the temperature to the desired level and has nothing to do with microbial killing action.
4. Steam that contains no excess air, no liquid water drops, and no solid particle contaminants.
5. 15 minutes.
6. It is necessary to use higher steam pressures to achieve the minimum temperatures required for sterilization.
7. Containers with non-perforated bottoms. Because air cannot escape downward through the container and air pockets would result. Non-perforated bottoms also would collect and allow the water in the steam to pool.
8. Because steam must contact all surfaces of the items, and it cannot penetrate dirt, organic material, grease, or oil.
9. The exposure time must allow complete steam penetration to all parts of the load, and some materials are penetrated more easily than others.
10. Four of the following:
    (1) Steam sterilization is relatively easy and safe.
    (2) Steam sterilization is the fastest method.
    (3) Steam sterilization is the least expensive method.
    (4) Many items used in surgery, such as metal instruments, are safely sterilized by steam.
    (5) Most steam sterilizers have automatic, pre-set controls that make each type of sterilization cycle virtually “fool-proof.”
11. The heat and moisture can damage or destroy the items.
12. Three of the following: oils, greases, powders, components of some equipment, dirt, and organic soilage.
13. The quality of the steam is difficult for the operator to monitor. If the steam is not pure, air pockets may form in, moisture may collect on, or solid particles may stain items being sterilized.

219

1. The steam compresses the air to the bottom-front of the sterilization chamber. A screened drain outlet is located in the bottom-front of the chamber; as the air is forced downward, a valve opens to allow the cooler air to escape.
2. When the internal thermometer, located in the discharge line, measures that the proper temperature is reached.
3. 30 minutes. Because even though the steam kills all organisms in 15 minutes, the steam can take some time to penetrate and heat all items.
4. The heat-up period, the thermal death period (kill time), and the safety factor period.
5. By using a pump to literally “suck” the air out of the chamber, creating a near-perfect vacuum, before the steam is introduced into the chamber. This creates a near-perfect vacuum before the steam is introduced into the chamber which allows for rapid air removal; thereby resulting in faster (virtually instantaneous) and more positive steam penetration of the entire load.
6. 270–276° F.
7 (a) Gravity displacement cycle; (b) Chamber pressure of 27 to 28 psi, and a temperature between 270 and 274° F.
8. Three minutes.
9. Items intended for implantation.
10. (1) The wash cycle washes the instruments in a detergent solution. The method used to wash the instruments—and the effectiveness of the wash—depends on the sterilizer. Most washer-sterilizer chambers fill with water and use “jets” to agitate the water to clean the instruments. A few washer-

sterilizers use “spray-arms” to wash the instruments. After the contents are washed, they are usually rinsed with clean water.

(2) Most washer sterilizers use a standard three- or 10-minute “flash” cycle at 270° F as the sterilize phase of the cycle.

220

1. To ensure the passage of steam meets minimal resistance from the top to the bottom of the chamber and throughout the load. Also, by not overloading the sterilizer, the tendency for air pockets to form in the load is reduced and load drying time is shortened.
2. Place all packages, trays, and sets (except rigid containers) on edge with the longest side of the pack on the rack shelf. Place receptacles such as basins and bowls on their sides. Tip wrapped packages slightly forward. Place rigid containers flat on the shelf. Allow at least three inches between the top of the sterilizer chamber and the topmost packages of the load.
3. To prevent air pocket formation, to ensure that steam freely contacts all surfaces, and to prevent condensation from being trapped in containers during load cool down.
4. Three inches.
5. Place paper and plastic peel packaged items on edge with the plastic side of one package facing the paper side of the adjacent package. To ensure this position is maintained during the cycle, and to provide easier handling, use wire baskets to hold the peel packaged items on the rack or cart shelves.
6. Check the chamber pressure gauge or digital readout to ensure it reads “zero.”
7. Stand slightly towards the hinged side, **never** directly in front of the opening side of the chamber. To greatly reduce the likelihood of a steam burn or other injury as you open the sterilizer door.
8. It helps any remaining moisture to evaporate, and makes the load slightly cooler and safer to transport to the sterile supply cooling area. It also reduces the likelihood of condensation occurring within the packs, which results if the hot items are exposed to cool room air too quickly.
9. Water droplets and visible moisture.
10. Handle items as little as possible by transferring them directly from the sterilizer to a drying rack or table. Avoid placing the hot items on cold surfaces. Place them on well-padded, fabric covered surfaces to prevent condensation.
11. (1) Clean the chamber, door, trays, carriages, and racks with a mild detergent; rinse with clean water.
    (2) Remove and clean the chamber drain strainer or plug screen.
12. By flushing with a solution of trisodium phosphate and hot water, or other manufacturer recommended product. Mix one ounce of trisodium phosphate to one quart of water or use a non-phosphate detergent. Follow this by flushing the drain with one quart of hot water.
13. People—somebody made a mistake.
14. Air may not be completely removed from the load and steam may not circulate freely; a mixture of air and steam will cause a lower temperature.
15. Qualified maintenance personnel or manufacturer’s representatives; because most OR and SPD personnel are not technically trained to repair or adjust sterilizers.
16. Changes in the water and steam quality supplying the sterilizer.

221

1. It inactivates critical microbial cell systems.
2. 0.2 percent.
3. The sterilization processor automatically aborts the cycle and prints out the reason the cycle aborted.
4. General processing tray.
5. Refer to the manufacturer’s recommendations.
6. Verify the expiration date, make sure the container is intact, and gently squeeze the bottom of the container to make sure the powder is soft.
7. Make sure the plastic hose connected to the aspirator probe is not kinked.
8. 122 to 131° F (50 to 55° C); 12 minutes.

9. Through a filtering system where tap water is filtered through two external prefilters in addition to an internal micro filtration system.
10. Items that cannot be submersed in liquid.
11. Failure to place caps on these devices may result in damage and costly repairs.
12. Devices with lumens need to be positioned so as to allow the liquid sterilant to flow upward through the lumen.
13. Every load.
14. 175 or greater.
15. Press the “cancel” button, and the inflatable seal will deflate.
16. Everything inside the processor—instruments and devices, processing container, and processing tray.
17. Bacillus subtilis or Bacillus stearothermophilus spore strips.
18. Contact with any unsterile surface.
19. 56° C.
20. Every 24 hours.
21. It ensures all electro/mechanical systems and the sterile water filter are functioning correctly.
22. The processor will prohibit you from initiating any cycles until the problem has been corrected and a successful diagnostic test has been completed.
23. A soft cloth dampened with 70 percent isopropyl alcohol.
24. Replace the aspirator assembly.

222

1. The hydrogen peroxide plasma interacts with cell membranes, enzymes, and nucleic acids to disrupt the life functions of the microorganisms.
2. A message screen, status indicator lights, paper printout, and beeps.
3. Vacuum, injection, diffusion, plasma, and vent.
4. One hour.
5. It changes from red to yellow.
6. Metal trays block the radio frequency waves.
7. If the sterilizer detects moisture, it may cancel the cycle.
8. Items with cellulose such as woven textiles with cotton fibers and paper products or items that absorb liquids.
9. Arrange items in a manner that allows the hydrogen peroxide and plasma to surround them. Do not stack instrument trays.
10. They should be placed flat on the shelves. *Do not stack trays or basins within the trays*.
11. Position them on edge and arrange them so that the transparent side of the pouch faces the opaque side of the next pouch.
12. *Bacillus subtilis* var. *niger* spore strips; biological testing should be conducted at least once per day.
13. At the back of the sterilization chamber, on the bottom shelf.
14. Within 15 minutes of cycle completion.
15. Wipe them down with a mild detergent.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

Do not return your answer sheet to AFCDA.

49. (214) Which statement *best* describes an *intermediate-level* disinfectant?
    a. It is not sporicidal and kills only less resistant bacteria and viruses.
    b. It is sporicidal, bactericidal, and virucidal with sufficient contact time.
    c. A chemical agent that kills most resistant bacteria and viruses, but not spores.
    d. Bacterial destruction is confined to vegetative bacteria and with sufficient exposure times, tubercle bacilli.

50. (214) The absolute definition of sterilization is a process that
    a. kills all microorganisms except spore forming bacteria.
    b. attacks only vegetative bacteria, fungi, and the less resistant organisms.
    c. destroys all living microorganisms, including bacterial spores and viruses.
    d. reduces the bioburden of an item to a level that makes it safe for handling.

51. (215) The sterilizing agent most commonly used in hospitals is
    a. dry heat.
    b. moist heat.
    c. ethylene oxide.
    d. glutaraldehyde.

52. (215) Peracetic acid sterilization requires the item to be
    a. wrapped.
    b. immersed in solution.
    c. high-temperature tolerant.
    d. subjected to an electromagnetic field.

53. (215) Most glutaraldehyde solutions
    a. are not capable of sterilization.
    b. are not capable of high-level disinfection.
    c. sterilize an item after a minimum of 10-hours of immersion.
    d. sterilize an item after a minimum of 10-minutes of immersion.

54. (216) How does temperature normally affect a disinfecting agent?
    a. Temperature does not affect disinfection.
    b. When temperature increases, effectiveness increases.
    c. When temperature increases, effectiveness decreases.
    d. When temperature decreases, effectiveness increases.

55. (216) Chemical agents for disinfection are primarily
    a. gases.
    b. tablets.
    c. liquids.
    d. powders.

56. (216) When disinfecting instruments that have lumens, what action is taken to ensure both inner and outer surfaces are completely contacted by the chemical agent?
    a. Water is blown out of the lumens.
    b. A syringe is used to flush the lumens with disinfectant.
    c. Gauze is inserted into the lumens to "wick" the disinfectant inside.
    d. The lumens are scrubbed with a hard-bristle brush to remove caked-on soil.

57. (216) If items are not completely dry before being immersed in a disinfecting solution, the excess moisture may mix with the disinfectant and
    a. superheat the item.
    b. oxidize surfaces of the item.
    c. increase the concentration of the disinfectant.
    d. decrease the concentration of the disinfectant.

58. (217) Why should alcohol *not be used* on lensed instruments?
    a. It dissolves the cement holding the lens in place.
    b. It is leaves a residue on the lens.
    c. It dissolves the lens coating.
    d. It corrodes the lens.

59. (217) What type of disinfecting agent is the agent of choice for environmental surfaces contaminated with fecal matter?
    a. Phenolics.
    b. Chlorine compounds.
    c. Mercurial compounds.
    d. Quaternary ammonium compounds.

60. (218) Which of the following statements *best* defines saturated steam?
    a. Steam that is mixed with air.
    b. Steam under extreme pressure.
    c. Steam that is treated with anti-corrosion chemicals.
    d. Steam containing a maximum amount of water vapor.

61. (218) Which of the following is *not* a principle of steam-under-pressure sterilization?
    a. The steam must be saturated.
    b. The steam must be "pure" or free from air contamination.
    c. The steam must have access to all surfaces of items being sterilized.
    d. The steam pressure must be high enough to penetrate the cell walls of bacterial spores.

62. (218) An *advantage* of steam sterilization is
    a. steam is the least expensive method.
    b. steam can be used to sterilize all types of materials.
    c. steam destroys microorganisms slowly, but completely.
    d. steam is an effective sterilant even when mixed with air.

63. (219) A 30-minute exposure period at 250° F is most commonly used for sterilization in a
    a. prevacuum sterilizer.
    b. peracetic acid sterilizer.
    c. ethylene oxide sterilizer.
    d. gravity-displacement sterilizer.

64. (219) What are the sterilization temperature and the *minimum* exposure time period for a typical prevacuum sterilizer?
    a. 250–254° F; four minutes.
    b. 250–254° F; ten minutes.
    c. 270–276° F; four minutes.
    d. 270–276° F; ten minutes.

65. (219) What is the *minimum* exposure time for unwrapped instruments in a flash sterilizer which is set at 270–274° F?
    a. Two minutes.
    b. Three minutes.
    c. Five minutes.
    d. Seven minutes.

66. (220) At least how many inches should there be between the top of the steam sterilizer chamber and the topmost packages on the load?
    a. One.
    b. Two.
    c. Three.
    d. Six.

67. (220) When the alarm sounds on a steam sterilizer, what should you do *next*?
    a. Allow sterilized items to cool to room temperature.
    b. Open the door slightly to allow residual steam to vent.
    c. Check the outside wrappers of every item for signs of wetness.
    d. Check the gauge or readout to ensure there is no pressure in the chamber.

68. (220) What should you do after the sterilization cycle is complete and the steam sterilizer has been allowed to vent?
    a. Allow the load to cool down.
    b. Check the sterilizer chamber pressure.
    c. Check the outside of wrappers for signs of wetness.
    d. Remove sterilized items to a padded fabric covered surface.

69. (220) Most errors that cause sterilization failure originate with
    a. people.
    b. equipment.
    c. water quality.
    d. steam quality.

70. (220) Which of the following is considered to be an error in steam sterilization?
    a. Sterilizing an instrument set that weighs 16 pounds.
    b. Removing wrapped items from the sterilizer when damp.
    c. Leaving a load in the sterilizer for 15 minutes after opening the door.
    d. Loading all items in a manner that will prevent formation of air pockets.

71. (221) What is the temperature range of the sterilization cycle in a peracetic acid sterilizer?
    a. Between 112 and 121º F.
    b. Between 122 and 131° F.
    c. Between 215 and 230º F.
    d. Between 270 and 285º F.

72. (221) What happens after you press the start button on a peracetic acid sterilizer?
    a. The sterilizer handle will lock.
    b. Instruments are rinsed prior to sterilization.
    c. Instruments are submerged in water and sterilant.
    d. A cup cutter releases the sterilant powder into the processor.

73. (221) When performing biological monitoring, what should you do *before* opening the envelope with the spore strip?
    a. Put on gloves.
    b. Incubate a control strip.
    c. Set the incubator for 37 or 56 degrees Celsius.
    d. Label the vial with the load number, date, and your initials.

74. (221) How often should a diagnostic test be run on a peracetic acid sterilizer?
    a. Every load.
    b. Every other load.
    c. Every 12 hours.
    d. Every 24 hours.

75. (222) Once instruments have been loaded into a hydrogen peroxide plasma sterilizer, what should you do next?
    a. Run diagnostic test.
    b. Press the start button.
    c. Place a chemical indicator in each tray and peel pack.
    d. Verify the status of the hydrogen peroxide plasma cassette.

76. (222) Once the sterilization cycle is complete for a hydrogen peroxide plasma sterilizer and you have opened the door, what should you do next?
    a. Run diagnostic test.
    b. Print a report of the conditions of the sterilization load.
    c. Check to make sure the chemical indicator strip has changed to red.
    d. Check to make sure the chemical indicator strip has changed to yellow.

77. (222) All items placed in a hydrogen peroxide plasma sterilizer must be
    a. dry.
    b. metal.
    c. moist.
    d. plastic.

78. (222) How often should biological testing be conducted and documented for hydrogen peroxide plasma sterilizers?
    a. Every load.
    b. Every 30 loads.
    c. At least once per day.
    d. At least once a week.

Please read the unit menu for unit 5 and continue ➔

Student Notes

Unit 5. Maintaining and Monitoring Sterility

AFTER STUDYING THE PREVIOUS LESSONS, you should realize that effective sterilization hinges on the right combination of numerous factors. If proper procedures are not followed in instrument and supply processing, or if a mechanical breakdown occurs in the sterilizing equipment, sterilization fails to occur. Due to the constant risk that sterilization errors will be made, sterilizers have built-in ways to mechanically monitor conditions in the cycle, and chemical and biological indicators help to verify items were subjected to the sterilizing conditions. These monitoring devices not only help prevent sterilization errors, but also warn the operator when errors do occur so they may take appropriate corrective action before patients are harmed.

The more advanced practices of surgical asepsis covered in this unit include sterile technique (often referred to as aseptic technique) and how to open and prepare sterilized equipment for use in the surgical environment.

5–1. Sterilization Process Monitoring

This section describes several different methods commonly used in the OR and sterile processing to monitor, verify, and record steam and ethylene oxide sterilization processes. Our discussion is divided into two lessons. First, we cover the basic methods of monitoring and verifying sterility, and second, we focus on two types of monitoring tools: sterilizer test packs and sterilization cycle documentation.

223. Monitoring sterilization cycles

To check for proper functioning of the sterilizer and verify sterilization efficiency, you must become familiar with various mechanical, chemical, and biological monitoring systems. Mechanical indicators record the physical conditions in the sterilizer, chemical indicators show that certain sterilization parameters have been met and biological indicators confirm that microbes were destroyed—at least those microbes contained in the test pack—during the sterilization process.

Mechanical indicators

Mechanical indicators are devices used to measure and monitor various conditions of the sterilizer. Mechanical indicators include thermometers, gauges, timers, recording devices, and other devices that monitor the various phases of the cycle, or that measure other conditions of the sterilizer. Although not all sterilizers have all the mechanical controls listed below, all sterilizers have some of them.

Thermometers

Thermometers, or temperature sensors, are generally located in the exhaust line of the sterilizer. They measure the internal temperature of this line which, theoretically, is the temperature of the coolest area inside the sterilizer chamber. The thermometer continuously measures the temperature in the sterilizer and transmits this temperature reading to a gauge or other readout device on or near the sterilizer control panel.

Gauges

Gauges are found on many sterilizers, particularly on older models. Gauges are used to measure the jacket pressure of a steam sterilizer and also to measure the chamber pressure of sterilizers. Some sterilizers also use a temperature gauge as one of the devices used to report the sterilizer chamber temperature registered by the internal thermometer.

Timers

Timers are primarily used to monitor the exposure period of the sterilization cycle. The timer is generally set by the operator before starting the cycle, then it automatically controls the exposure period. Other timers are built-in and used to automatically control various phases of different sterilization cycles. The dry cycle of a steam sterilizer and the rinse cycle of a peracetic acid sterilizer are two examples of timed phases of sterilization.

Recording devices

Many recording devices simply provide the operator with information about the conditions during the sterilization load. The temperature and pressure gauges discussed previously are examples of these types of recording devices. Many sterilizers have digital displays that show conditions such as the temperature, pressure, phase of the sterilization cycle, and the time remaining in the cycle. By closely monitoring the temperature and pressure at various points in the cycle, the operator can quickly identify problems or discrepancies and take corrective action.

Most national standards recommend that mechanical control devices be monitored by personnel operating the sterilizer at the beginning of, during, and at the end of every sterilization cycle to verify proper function. Standards also recommend that all time and temperature recording devices and pressure-temperature gauges be calibrated at least semiannually, and immediately after any repairs affecting sterilizer performance.

Recording devices are also used to provide automatic documentation to show that various sterilization parameters have been met. The two most common recording devices for documentation are round charts (also called graphs), and digital printouts. The round charts provide a constant record of the sterilizer conditions. They usually record only the temperature and time of exposure in a steam sterilizer. These charts are changed daily, usually in the morning before cleaning the sterilizer. The digital printouts usually list the time, temperature, pressure, and phase of the sterilization cycle at regular intervals throughout the cycle. The paper supply should be checked at the start of each day. The chart or paper strip should be maintained with the sterilization records (discussed later). As a minimum, the chart or digital printout should be labeled with the sterilizer number, the date, the time, and the load or lot control number. Most local policies also require the operator’s name to be documented on the record.

Other mechanical control monitors

Most sterilizers have other mechanical devices or controls that relate to safety or automatic operation. These automatic controls include:

- The sterilizer door safety lock that prevents opening the chamber if the cycle is not complete or if dangerous conditions exist in the chamber.
- The cycle phase controls that condition the load, allow the sterilant to enter, time the sterilizing cycle, exhaust the sterilant, and dry or aerate the contents.
- Alarms that tell the operator when the cycle is complete. Some sterilizers have alarms to warn if conditions do not meet the normal operating parameters of each phase of the cycle.

One important thing to remember: While mechanical devices do much to prevent faulty sterilizer operation, they generally *do not* detect cool air pockets or other abnormalities in the sterilization chamber. Since cool air pockets are the leading cause of sterilizer failure, additional controls are necessary for complete safety. *Do not* rely on mechanical monitors as the sole method to determine

sterilization effectiveness. Other indicators are used to more accurately monitor sterilization; some of these are chemical sterilization indicators.

Chemical indicators

The basic purpose of all chemical indicators is to provide hospital personnel a visual method of determining whether items have been subjected to a sterilization process. A variety of chemical indicators are available and commonly used. They generally fall into one of two categories: external and internal chemical indicators. The tape used to seal packages, the arrows or locks sealing rigid containers, and the outside of peel-packs are generally impregnated with a chemical that turns a specified color during the sterilization cycle. These are external chemical indicators. Paper strips treated with chemicals that change colors after sterilization are placed inside each package being sterilized. These strips are known as internal chemical indicators. Other types of chemical indicators include chemically treated disks, solid tablets, or solutions sealed in plastic or glass containers. These are usually used for special purposes such as monitoring a washer-sterilizer cycle.

Virtually all chemical indicators are designed to change to a specific color when subjected to one or more of the conditions required for sterilization (temperature, humidity, pressure, gas concentration, etc.). For example, the chemically impregnated areas on steam sterilizer tape usually turns a uniform dark brown color when exposed to the high temperatures of a steam sterilization process. It is extremely important for you to know that *changes in chemical indicators do not guarantee sterility*. The change only shows that the item was subjected to the sterilization process.

Chemical indicators are used on the outside and inside of all packages. External indicators provide hospital personnel a quick way of checking whether or not an item has been subjected to the sterilization process. Internal chemical indicators serve the same purpose as external ones. They are placed in all packages in an area most difficult for the sterilant to reach, usually the geometric center of the package. They provide a means of indicating whether or not the internal contents of a package were exposed to the same sterilization conditions as the outside of the pack. Processing personnel should check external indicators immediately after sterilization. The end users (often the scrub and circulator) should check external indicators before and internal indicators after each item is opened for use. Consider any variations in the degree of color change of a chemical indicator as a sign that a sterilization failure has occurred. *If the physical changes are not uniform, consider the item unsterile and discard or reprocess the package contents.*

Air removal test

A special chemical indicator is only used in *prevacuum steam sterilizers*. It uses a chemically treated paper sheet or strip to test for complete removal of air from the sterilizer chamber during the pre-vacuum phase. This air must be removed so that steam can penetrate the load instantaneously. You must understand that *this test only checks for air removal; it does not determine adequate heat or time exposure*.

The air removal test must be performed daily on each prevacuum sterilizer before any sterilization loads are run. Running an empty “warm-up” cycle may help prevent false air-removal test failures due to “cold” sterilizers. The air removal test device may be a commercially manufactured testing instrument or it may be made locally. If using a commercial device, follow the manufacturer’s instructions explicitly. The locally prepared air removal test is commonly referred to as a Bowie-Dick test. The most common method for assembling a Bowie-Dick test pack is as follows:

1. Use laundered linen hand towels. Fold them to about 9 × 12 inches. Folding a standard cloth hand towel in half, then in half again, is about the right size.
2. Fold enough towels to make a stack 10 or 11 inches high. The number of towels varies with the type of towels used.
3. Place a commercially manufactured Bowie-Dick test sheet in the middle of the stacked towels. If you do not have a commercial test sheet, you can make one by placing three or four

8-inch pieces of steam sterilizer tape on a towel, or sheet of paper, in a crisscross ✖ pattern. The basic idea is to create a pattern of chemical indicators extending from the center of the pack to the edges.

4. Wrap the towels (with positioned indicator sheet) in a single wrapper, loosely applied.
5. Place the pack horizontally, at the bottom front, directly above the drain strainer, of an empty prevacuum sterilizer chamber. (It may be placed in this position on the sterilizer cart or rack.)
6. Set the sterilizer controls for a 3.5 minute exposure time, if possible, at 273° F (133° C). Run a standard cycle; the dry cycle may be omitted to save time. The actual exposure time period should *never exceed* four minutes. If it is longer than four minutes, the results are invalid.
7. Remove the test pack as soon as the cycle is complete. Be careful removing the test pack—it is hot—and should be handled by wearing thermal protective gloves.
8. After removing and opening the pack, have the test sheet checked by someone trained in interpreting the results.

The test sheet color change pattern shows residual air, if any, that remained in the pack during the sterilization cycle. *The uniformity of the change*, not the intensity, *is the most significant factor*. *Variations* in the overall color change pattern indicate *inadequate* air removal and medical maintenance personnel should be called immediately.

NOTE: A prevacuum sterilizer that fails a Bowie-Dick test may be operated as a standard gravity displacement steam sterilizer, providing routine biological testing (discussed next) demonstrates effective sterilization in the gravity displacement mode.

Biological monitoring

Testing sterilizers with biological indicators is considered the best method available for determining the efficiency of a sterilizer's ability to sterilize an item. Like other sterilization indicators, biological indicators *do not* prove each item in the load is sterile. It does, however, prove that the sterilizer conditions killed the microbes in the testing medium.

The exact biological indicator used varies, but most use commercially prepared ampules or vials that contain a strip or dot impregnated with the recommended test bacteria. The bacterium used for biological testing of steam sterilizers is *Bacillus stearothermophilus*. The ampule or vial also contains a liquid growth medium. To expose the spore strip to the medium, the ampule must be activated; usually by crushing either the top or the sides of the test indicator. The test ampule is activated after it is subjected to the sterilization cycle. The ampule or vial is then placed in an incubator. If the sterilizer fails to kill all microbes in the test ampule, the growth medium changes color (called a positive result) to indicate the bacteria survived. If the sterilization cycle killed all microbes in the ampule, the color of the growth medium generally does not change (a negative result).

A *control* indicator is required to show that the microbes in the test ampules used are viable and will grow when subjected to the same conditions as the test indicator. At least one control indicator must be processed from each lot number of test indicator used, and in each incubator used. The control indicator is simply a biological test indicator that is *not subjected* to the sterilization process. The indicator is activated and placed in the same incubator as the test indicator. The test indicator is compared to the control indicator each time it is "read," usually at 12, 24, and 48 hour intervals. If the control indicator has changed color (is positive), and the test indicator *has not* (is negative) at each reading, the sterilization cycle is considered acceptable. If the control indicator does not indicate microbial growth (change colors), the test results are inconclusive and the sterilization cycle is not considered valid. Control ampules that *do not* turn positive indicate a problem with either the incubator or with the microbes in the test ampule. The incubator and other ampules from the negative control lot number should *not* be used for sterilizer testing until the problem is identified and corrective action is taken. On the other hand, if a test ampule does change colors (is positive), the

problem is always assumed to be with the sterilization cycle. Any cycle that results in a positive test result is not acceptable, and the contents of the cycle must not be used.

The biological test indicator is placed in a *test pack* that is placed in the sterilizer chamber in an area that is difficult for the sterilant to reach, usually directly over the chamber drain. These test packs may be commercially manufactured, or they may be made locally; test packs are discussed later.

According to nationally accepted standards, biological test packs must be run after initial installation, after any major repairs to the sterilizer, and before the sterilizer is placed in service.

- Biological test packs should also be run in each steam sterilizer at least weekly, but preferably daily.
- A biological test pack should also be run in every sterilizer load containing implantable devices. The devices should be quarantined until the results of the biological testing are confirmed (if possible).

If a facility uses the event-related method for shelf-life, every sterilization load should be tested with a biological indicator.

224. Sterilization "challenge tests" and documentation

We mentioned in the last lesson that you place biological indicators in test packs before subjecting them to a sterilization process. Since there are several different types of test packs, ensure you become familiar not only with any commercial packs that may be routinely used in your facility, but also with the locally prepared test packs.

Locally prepared sterilizer test packs

Numerous commercially manufactured test packs are available for use; too many to practically describe in this course. If your facility uses commercially prepared packs, ensure you follow the manufacturer's directions for use. Even if your hospital does not routinely use locally prepared test packs, you need to know how to make and use them; they are used during contingency situations, and may be used when commercial packs are not available.

Test packs for steam sterilizers

There are two types of locally prepared test packs that are acceptable for either gravity displacement or prevacuum steam sterilizers: the traditional two-indicator test pack and the one-indicator test pack. The following tables list the contents and construction of each.

2-Indicator Test Pack (Traditional)	
Contents	**Instructions**
12 laundered, fan-folded linen hand towels 3 fabric gowns 5 laparotomy sponges, 12 x 12 inches 1 fabric drape sheet 30 gauze sponges, 4 x 4 inches 2 biological test indicators 1 internal chemical indicator	• The linen and gauze are stacked into two equal piles with the towels in the center. • Two biological indicators are placed in the center of the pack, separated by a hand towel. • The chemical indicator is placed in the center, one layer above or below the biological indicators. • The pack is double wrapped; it should be about 12" x 12" x 20" and weigh 10–12 pounds.
1-Indicator Test Pack	
Contents	**Instructions**
16 laundered hand towels, folded to 9" x 9" 1 biological indicator 1 chemical indicator	• The towels are stacked to form one pile. • The biological indicator and chemical indicator are placed side-by-side in the geometric center of the stack, between the seventh and eighth towels. • The pack is not wrapped, but is double taped to secure it.

If using the two-indicator test pack, sterilize it on its side. If using the one-indicator test pack, sterilize it flat. Regardless of the test pack used, place it on the sterilizer cart or rack in the bottom front of the sterilizer, just above the chamber drain. *The biological test pack should be run during a fully loaded, normal sterilization cycle.*

Interpreting test results and supply recall procedures

If incubated biological indicators show negative results (no bacterial growth), you can be reasonably assured that the sterilizers are functioning properly and personnel are following proper sterilization procedures. However, if the results of the test are positive, then the sterilizer is re-tested with another biological test pack immediately. This is necessary because false positive results often occur. Do not run any loads in the sterilizer after the load that includes the second test pack. If the second test is positive, remove the sterilizer from service, notify maintenance personnel, and implement a recall of all items processed in the suspect sterilizer. If maintenance checks indicate proper sterilizer function, then supply processing, wrapping, loading, and operating techniques are reviewed and revised as necessary.

A recall of items includes sending out a *written notice* to the using activities that received the sterilized items. Identify the items in question by sterilization lot number (or other identifying data). Include with the recall notice the number and type of items affected and outline what to do with the items (discard or return for reprocessing). Follow local policy established for item recalls; this usually includes completing an AF Form 765, Hospital Incident Statement, because the impact of a sterilization failure can affect many areas in the hospital. Your local policies and procedures specify what steps to follow when biological tests are positive for bacterial growth.

Sterilization record keeping

All biological and chemical indicator test results must be documented to facilitate item recalls and act as quality assurance tools to ensure consistent sterility of patient care items. Information and records that are normally kept on file include, but are *not* limited to:

- Date and time of test (Julian date is often used).
- Sterilizer number.
- General description of load contents.
- Sterilization cycle number.
- Sterilization conditions (temperature, exposure time).
- Results of biological control indicator.
- Results of biological test indicator(s).
- Results of, and usually the indicator from each test pack (to include air removal test indicators).
- Completed recorder charts or computer printouts showing sterilization cycle parameters.
- Name of sterilizer operator (or initials).

The exact method used to document sterility depends on local policy developed to meet state, national, and Air Force standards. A repair or maintenance log should also be kept for each sterilizer.

Summary

To ensure locally processed items have been subjected to the proper conditions for sterilization, each sterilization cycle must be monitored. This section covered the mechanical, chemical, and biological indicators used to ensure items used on surgical patients are as biologically safe as possible. It also described in detail the methods for constructing test packs to test specific sterilizers. Ensure you learn and follow the specific methods your facility uses to monitor sterilization cycles.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

223. Monitoring sterilization cycles

1. Name four types of mechanical indicators used on sterilizers.

2. What does a thermometer (or temperature sensor) measure and where is it located in the sterilizer?

3. What do the gauges on a steam sterilizer measure?

4. How often and when are sterilizer recording charts usually changed?

5. What minimum information should be labeled on a sterilizer chart or recording strip before it is placed with the sterilization records?

6. What is the basic purpose of a chemical indicator?

7. Where are internal chemical indicators placed in a pack?

8. What do variations in the degree and uniformity of color changes on a chemical indicator signify?

9. What special chemical indicator test is only used in prevacuum steam sterilizers? What does this test measure? Describe the most common method for locally assembling this test pack.

10. How and where is the pack from question #9 placed in the sterilizer? At what time and temperature setting is this test pack run?

11. What is the best available method of determining sterilizer efficiency?

12. Name the bacterial spore used to test steam sterilizers.

13. What is a control biological indicator and how is it used?

14. How often should biological test packs be run in steam sterilizers?

224. Sterilization “challenge tests” and documentation

1. Where is a biological test pack placed in a steam sterilizer?

2. What actions are taken if a biological indicator from a test pack shows positive bacterial growth?

3. List six types of information or records of sterilization that are normally kept on file.

5–2. Storing and Handling Sterilized Items

After sterilization, patient care items are usually stored temporarily until they are selected for patient care use. Wrapped, sterile items are constantly being picked up and handled. Consequently, great care must be taken to protect them from being contaminated or damaged. Commonly used wrapping materials do not provide total protection against accidental contamination; therefore, strict environmental control of sterile storage areas has to be maintained. All personnel who process, store, and distribute sterile items must know and follow proper procedures for handling them. To ensure all sterile items are readily available when needed, they are stored in a neat and orderly fashion. To ensure that all items maintained in storage remain sterile, the stock is rotated and periodically checked for outdates.

This section covers the proper methods for storage and handling of sterile supplies and instruments to include procedures for checking outdates and rotating stock. We also discuss the factors that affect the shelf life of sterile items.

225. How to handle and store sterile supplies

The protective barrier around sterile items, provided by packaging materials, can be breached—resulting in package contents contamination—by improper handling and storage. If placed on a wet surface, handled with damp or wet hands, or stored in a high-humidity area, moisture can “wick” into a package, carrying microorganisms from nonsterile surfaces into the sterile package (strike through). If a package is dropped on the floor, dust or dirt may be forced through the packaging. If too loosely wrapped or if placed in too big a package, the item may not fit on the storage shelf properly and the package may be torn, scraped, punctured, or otherwise damaged. Proper handling of sterile items prevents these methods of contamination.

Proper handling of sterile items

The basic rule to follow when handling sterile items is to *handle them as little as possible between the time of sterilization and their use*. As stated previously in the sections covering unloading sterilizers, the sterilized items should remain on the sterilizer cart until they are cool. They should not be handled or even touched during this time. Even when steam sterilized items are cool to the touch, if you place them on a cool storage shelf, condensation may occur. If the items must be handled before they are

cooled, they should be handled as little as possible. Be certain to wear clean, dry, gloves when doing so. *Always check the integrity of a sterile package:*

- Immediately after sterilization.
- When putting the item in storage.
- When removing the item from storage.
- Just before use.

Packages that are torn, soiled, wet, or distorted are considered contaminated; *do not* use them. *If a sterile item falls or is dropped on the floor, it is contaminated because the force of the impact can drive dirt and microbes into the package.* Discard contaminated disposable items and reprocess reusable ones. If the contaminated package contains linen items, launder them before they are wrapped and sterilized again to prevent fabric superheating.

Avoid picking up and moving packages when performing sterile supply inventories. If properly stored, you should be able to see and count them with minimal touching of the packages. *Do not* "squeeze" sterile packages to remove excess air after they are sterilized; the air should have been removed before the cycle. Squeezing excess air out of the package may result in unsterile air being sucked into the package.

When transporting supplies from one place to another; try to use a covered cart or basket—especially if traveling through non-restricted areas. Avoid hand-carrying items whenever possible; use a pillow case or plastic bag for small items, a cart for large items. If you must hand-carry a sterile item, hold it in your hands. Never carry items cradled in your arms or tucked under your arms; the excessive contact with your perspiration-prone skin may result in strike-through.

Storing sterile items

The basic principle behind storage of sterile items is simple: Once an item is sterile, it should be stored in a manner that keeps it sterile. Sterile storage is a temporary condition; it is a holding area for sterilized items until they are used.

Traffic is restricted in sterile storage areas to limit access and minimize traffic. This helps reduce the number of potentially contaminating incidents and excessive air movement that transports airborne contaminants from other areas.

Ideally, sterile items are stored in designated sterile storage rooms or areas. However, space limitations, types and amount of supplies, and other factors dictate the exact configuration of your storage areas. If sterile and nonsterile supplies must be stored in the same area, keep them strictly separated. *Do not* store them touching, next to, or even on the same shelf. If sterile supplies are stored with nonsterile supplies, the storage area should meet the environmental requirements for storage of the sterile items.

Sterile storage areas should be clean, free of dust, dirt, and vermin. They should be cleaned routinely in a manner similar to the methods used to clean the ancillary areas of the surgical suite.

The sterile storage area should have a positive-pressure ventilation system similar to the one used in each operating room. This type of ventilation system helps reduce the level of airborne microorganisms and dust in the storage room. According to the *CDC Guidelines for Environmental Control in Health Care Facilities*, a *minimum* of four exchanges per hour is recommended for sterile storage areas. To prevent excessive air movement, *do not* use fans in sterile storage areas.

Care must be taken to ensure sterile storage cabinets and shelves are kept moisture-free to prevent strike-through contamination of sterile packages. Temperature and humidity are controlled to prevent extremes. Keep the temperature between 68 and 73° F and the humidity no greater than 70 percent. The right combination of temperature and humidity is important because an environment that is too warm and too moist accelerates bacterial growth; one too cold is uncomfortable for workers.

Extremes of temperature and humidity can compromise package integrity and renders the item unserviceable.

Disposable items are typically delivered to the OR or SPD in bulk shipping containers or boxes. Remove the sterile items from these containers outside the storage area and transport them to the storage area on or in a clean supply cart. *Never bring boxes and shipping cartons into sterile storerooms because they harbor dust, microorganisms, molds, fungi, and insects.* Never use a shipping carton (commonly called an "outside box") as a sterile supply dispenser. Make sure that the transport carts you are using for sterile supplies are periodically cleaned and decontaminated with an approved detergent-germicide.

Closed or covered cabinets are the preferred method for storage of sterile items in Air Force facilities, but open shelves are acceptable. Regardless of the storage system used, store sterile supplies at least 18 inches below the ceiling, 8 inches above the floor, and 2 inches away from outside walls. The shelves should be non-porous materials to aid in cleaning (no wooden shelves). Never store supplies near or under sinks or pipes. If you do, you are inviting water contamination of your sterile supplies. Dust covers and covered storage bins help maintain the sterility of items, particularly supplies stored on open shelves.

Although closed shelves or cabinets offer greater protection against sterile item contamination, there are a couple of rules you must follow to ensure their purpose is not defeated. First and foremost, *keep the doors and drawers closed!* If the doors or drawers are open, it is not a closed cabinet. Another rule is—always open cabinet doors slowly. This is important because opening the door too fast can cause rapid air movement near the door opening that draws dust, dirt, and airborne contaminants into the cabinet. Opening the doors slowly also reduces the likelihood of a sterile item falling out of the cabinet and onto the floor.

Avoid overstocking shelves. Cramming packages together or stacking them too high, distorts and damages wrappers and package contents. Good supply management and inventory control prevents accumulation of supplies on your shelves. Ideally, you maintain only enough sterile supplies (both disposable and reusable) to satisfy weekly needs, plus a small reserve for emergencies. Store large, heavy items on lower shelves, and smaller, lighter items on upper shelves. This is done primarily as a safety precaution to prevent someone from being injured by a heavy, falling object. It also saves "wear and tear" on back, arm, and shoulder muscles.

Periodically clean all storage areas, shelves, cabinets, and bins with a detergent-germicide. This is usually done on a weekly basis in conjunction with "checking outdates." Remember to thoroughly dry all storage surfaces before placing sterile supplies in or on them.

226. Maintaining package sterility

To manage and control the number of sterile supplies maintained in your storage areas, you must understand and follow standardized policies and procedures for checking outdates, rotating supplies, and determining shelf life.

Checking for outdates

Checking outdates is simply checking the expiration dates (if used) or sterilizer control number, and the package integrity to make sure all items in sterile storage still meet the criteria for sterility. At least once a week, check all sterile supplies to ensure none are outdated. As mentioned in the previous lesson, you also check for expiration and sterile integrity each time you pull an item from storage and immediately before the item is opened for patient care use. Discard or reprocess any items found to be outdated, depending on the type of item, the manufacturer's recommendations, and local policies.

If a particular item is frequently discovered as outdated, the packaging method, stock level, or stock rotation may need adjusting. The item(s) in question may not even require sterile storage. Constantly reprocessing outdated items is a waste of supplies and manpower; it should be consistently monitored.

Over-ordering disposable items that have a sterility expiration date is also a waste of supplies and money if you end up throwing them out. This brings us to the next point—don't forget to check those *commercially prepared* sterile supplies for outdates. Although most prepackaged sterile supplies are considered "sterile unless package is opened or damaged," some items do expire; particularly those with drugs (like anesthesia block trays), culture media (as in culture tubes), or other chemical agents (like the chemicals in some blood collection tubes).

Rotating supplies

The problem of excessive outdates is virtually eliminated by proper stock rotation. The principle is simple—*first in, first out* (FIFO). This means that items placed in storage first, should be used first. Local policy dictates exactly how you rotate your in-house and commercially sterilized items; ensure you become fully familiar with these policies.

Do not place newly sterilized items on the shelf in front of "older" items. This causes the items toward the rear of the shelf to outdate before they are used. This is wasteful. Not only does it waste supplies but also wastes your valuable time by forcing you to discard or reprocess items unnecessarily.

Shelf life

Shelf life is the length of time a sterile item is assumed to remain sterile while in storage. Shelf life is event-related and depends on numerous factors, including the packaging used, the number of times a package is handled—and number of people handling it—between sterilization and use, the storage method used, and other factors.

The specific shelf life policy used in your facility is usually determined by the OR and SPD supervisors, working closely with the Infection Control Committee. The policy *must be written*, and should be based on experience, knowledge of current national standards, research data, input from infection control personnel, and hospital-specific needs and storage conditions.

Factors affecting shelf life

There are several factors that affect shelf life that supervisors take into consideration when establishing shelf life policies.

Packaging materials used

The primary purpose of the wrapping material or other packaging method used is to maintain sterility until the package is opened. How well a particular package does so affects the shelf life of a sterilized item. As stated earlier, commercially packaged items are usually considered sterile indefinitely—unless they are opened or the package integrity is otherwise compromised. Most manufacturers use packaging such as impervious plastic or plastic-coated wrappers that resist punctures, tears, and moisture strike-through. These packages often have additional layers of material surrounding the items that provides extra insurance against accidental contamination.

Supplies you process and sterilize also depend on their packaging materials to maintain their sterility. Some of the characteristics of packaging materials and their effect on shelf life include:

- How permeable or porous the package is.
- How long (under various conditions) the packaging retains its barrier capability.
- What length of time the manufacturer states the items packaged in their product can be considered sterile.

Cloth wrappers and paper wrappers are more porous than plastic wrappers and non-woven wrappers. Items wrapped in cloth or paper may be assumed to be contaminated more easily; thus have a shorter shelf life. Items wrapped in nonwoven wrappers or sealed in plastic dust covers are more resistant to microbial penetration, so are assumed to have a longer shelf life. Some packaging materials may break-down and lose their protective capability over time. If a package tends to break down, shelf life

is only good as long as the package retains its original capability. Manufacturers subject their packaging materials to numerous tests under different conditions to test their products effectiveness. If a manufacturer states the packaging maintains sterility for 30 days, the shelf life *cannot exceed* 30 days. If the manufacturer states the packaging can maintain sterility indefinitely, the shelf life may be indefinite or "until package is opened or damaged."

In addition to the type of packaging materials, sealing methods influence package integrity. Tape is commonly used to seal wrapped items; the tape may fail under certain environmental conditions. Heat sealing of plastic/paper peel-packs is an excellent method of ensuring package integrity and extending shelf life, especially if the sealer puts multiple sealing lines on the package.

Package handling

We discussed basic guidelines for handling sterile supplies in the last lesson, but handling also affects shelf life. The more times an item is handled, or the greater the number of people handling it, the greater the risk of contamination of the contents (and the shorter the shelf-life). Handling of sterile items may force unsterile air into a package, or it may result in "strike-through" from moisture on the hands, enabling airborne contaminants to enter the pack and compromise sterility. Packs wrapped in impervious materials, such as plastic, are less affected by repeated handling. Small items, particularly peel-packaged ones, commonly stored in bins or baskets, may be at high risk of contamination by personnel sorting through the packages; the repeated shuffling of the packages may eventually lead to seal failure or punctures in the wrapper caused by protruding contents or by rough handling of the items. Generally, the more times an item will be potentially handled, or the more people potentially handling it, the higher the risk of contamination is assumed, and the shorter the shelf life of the item.

Another package handling factor that affects shelf life is the training of the people who actually handle the items—the customers. Are they aware of and do they follow the proper procedures for handling and storing supplies? Do they maintain high standards of personal hygiene? Do they frequently wash their hands during the day, especially after removing gloves, touching a patient, handling contaminated items, and eating a meal? If the answer is "no" to one or more of these questions, then the shelf life of sterile goods in their department is questionable.

Storage environment

The storage environment, including the storage method used, the ventilation system, the humidity and temperature range, and how much (and what type) of "traffic" is in the room also influences shelf life. Closed cabinets may provide better protection than open shelves. The items on the open shelves may be more susceptible to events resulting in contamination; shelf life may be reduced. If items are not properly stored (too close to walls, ceilings or floors), the risk of moisture and dust contamination is increased. As stated before, high humidity and temperature can increase bacterial growth which may lead to an increased chance of package contamination and decreased shelf life. If vermin are present, the risk of contamination is high; insects are small enough to crawl under the wrapper flaps and enter the sterile inner areas of a package. Excessive air movement in the storage area brings in more airborne contaminants; thus reducing expected shelf life. Inadequate air exchanges allow dust and bacteria to settle on environmental surfaces, increasing the risk of contamination.

Quality control indicators

All items sterilized locally should meet the following criteria before being placed in sterile storage.

- Label each item with the identity of the contents and a load control or other traceability label. The load control number usually consists of the sterilizer number, Julian date, and load number. For example, a load control number might read **01–042–03.** The "01" is sterilizer number 1; the "042" is the Julian date, or numerical day of the year (the 042 date is 11 February); and the "03" stands for the third sterilization load (run in sterilizer #1) of the day. This is only an example of a load control number, the number used in your hospital may be

different, but it must be a unique number for each sterilization load so the contents of the load can be easily traced.

- The sterilizer load's mechanical recording device records are monitored and retained to verify sterilizer conditions such as time, temperature, and pressure.
- An internal chemical indicator must be placed inside every package sterilized. An external chemical indicator must be on the outside of each item.
- Biological monitoring must be accomplished according to current national standards.
- Daily air removal testing (Bowie-Dick) must be accomplished on *all prevacuum* steam sterilizers.
- The integrity of each package must be inspected before it is placed in storage and again before use.

Determining shelf life

Although the specific shelf life policy used in your treatment facility is determined by local policy as described previously, there are two basic methods used in Air Force facilities. The oldest, traditional method is *time-related*: items are considered sterile for a specific period of time. The other method is *event-related*: items are considered sterile indefinitely unless an event occurs to compromise the sterile integrity.

Time-related shelf life

The time-related method of shelf life involves labeling each item sterilized with a specific expiration date. When the expiration date is reached, the item is considered unsterile, even if the package integrity is intact. Labeling packages with an exact expiration date helps ensure they are rotated properly, and no item sits on the shelf for an overly-long time period. When the time-related method is used, the quantity of sterile items in storage should be kept to the minimum required to reduce the likelihood of unnecessary reprocessing of outdates.

The expiration date should be stamped, marked, or otherwise indicated on all items before the sterilization process. Many facilities use a self-adherent label, like the one shown in figure 5–1, with the expiration date and sterilization control number stamped on it. A label is placed on each item sterilized. Sterile supplies that have reached the expiration date are completely disassembled, reprocessed, and sterilized. When linen is part of the tray contents, it must be freshly laundered.

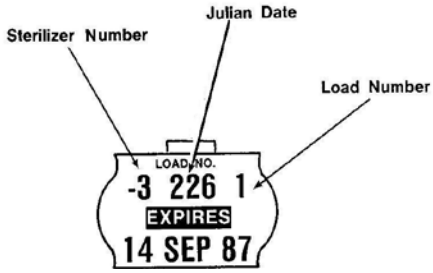

Figure 5–1. An expiration date/sterilization control label.

Local policy will dictate the recommended expiration dates for items sterilized within your facility.

Event-related shelf life

The event-related method of shelf life assumes an item remains sterile until an event occurs that compromises its sterility. Like the time-related method, each item is also labeled with a sterilization control number; the difference is that no expiration date is used. Figure 5–2 shows an example of a sterilization control label for an event-related shelf life item.

The Association for the Advancement of Medical Instrumentation (AAMI) has published standards for facilities electing to use the event-related method. Those standards are listed.

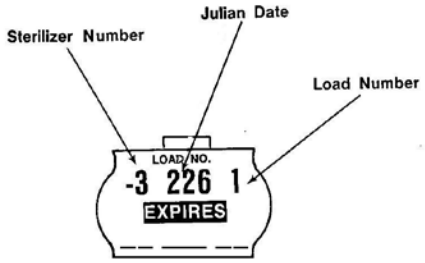

Figure 5–2. An event-related sterilization control label.

- Biological monitoring of steam sterilizers should be accomplished at least once a week. To obtain maximum sterilizer monitoring efficiency, run a biological test with every load. This will give you 100 percent testing of all sterilized products and the assurance that the conditions for sterilization were met on all sterilization loads. If you have poor steam quality or numerous sterilizer problems, it would be advisable to run a biological test with every load.
- Every item considered sterile indefinitely must have an exterior label indicating that the "contents are sterile unless the package is opened or damaged" or similar statement concerning the integrity of the package.
- Items in rigid containers are sterile for as long as the manufacturer recommends. If no recommendation is given; indefinite shelf life may be assumed as long as the filters remain in place, sealing valves/gaskets remain sealed, and the container securing devices/safety seals are intact.
- All items in compromised packages (damaged, torn, dirty, dusty, damp, and stained) are *not considered sterile*. They should be returned for reprocessing.
- Stock rotation must be practiced in all areas of the medical facility to ensure that items sterilized first are used first (remember FIFO).
- Facility-wide education and training must be provided on the labeling system used, on the proper handling and visual inspection of packages, stock rotation procedures, and use of items in dust covers. Written policies must be established and distributed to users on how shelf life is determined and how it is labeled on the products.

Summary

After patient care items have been wrapped and sterilized, sterility must be verified and the items must be protected from contamination until they are used. This section has familiarized you with the principles and methods of handling and storing sterile supplies. Procedures for checking outdates and a review of stock rotation guidelines were presented along with the concept of event-related shelf life and the major factors that influence shelf life determination.

By studying the material in this section, you should be able to better understand the supply storage and handling policies in your hospital. More important, your new-found knowledge will enable you to avoid making errors that contaminate supplies, waste valuable resources, and harm your patients.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

225. How to handle and store sterile supplies

1. Identify three ways sterile package contents can become contaminated.

2. What basic rule do you follow when handling sterile supply items?

3. When do you check the integrity of a sterile package?

4. What do you do with a sterile item that falls on the floor? Why?

5. Why are sterile supplies stored in a limited-access, enclosed area?

6. What kind of ventilation system is recommended for sterile storage rooms?

7. What temperature and humidity ranges are recommended for a sterile storage area?

8. Why are shipping cartons never allowed into a sterile storage area?

9. How far away from floors, ceilings, and outer walls should sterile supplies be stored?

10. What is the most important rule to follow when utilizing closed cabinets for supply storage?

11. How often are sterile supply storage areas usually cleaned?

226. Maintaining package sterility

1. How often do you check outdates on all sterile supplies?

2. What actions can be taken to help correct the problem of excessive outdates?

3. List three types of commercially prepared items that are likely to outdate?

4. What does the acronym FIFO mean?

5. Define the term “shelf life.”

6. What are some of the factors that influence shelf life?

7. List three packaging characteristics that may affect shelf life.

8. How does repeated handling of supplies affect the shelf life? Why?

9. What type of packaging is less affected by repeated handling?

10. List three criteria that locally sterilized items could be inspected for before being placed in sterile storage.

11. Briefly describe the time-related method of shelf life.

12. List six of the guidelines recommended in the AAMI standards for facilities electing to use the event-related shelf-life method.

5–3. Sterile (Aseptic) Technique

Surgical asepsis actually refers to all measures we use to prevent or reduce the numbers of pathogenic microbes, including environmental measures and personal measures. However, we often refer to sterile technique—the measures we use to prevent introduction of pathogens into the patient—as aseptic technique. Sterile technique is essential; it is our primary method of preventing wound infections.

During technical training, your instructors stressed proper performance of sterile techniques (you may have thought that they beat it into you) as you were required to perform each sterile task in a specific manner. This section builds upon the knowledge you acquired in tech school by focusing not only on how we perform certain sterile tasks, but also why we do them. For example, this section starts with aseptic principles relating to establishing sterile fields. You learned how to establish them in school, so our discussion focuses on the principles, or rationale, behind those methods. This section is not one to take lightly. Your knowledge and practice of asepsis is crucial to your patients, and to your effectiveness as a surgical technician, so study it closely.

227. Principles and rules of sterile technique

The over-simplified, “catch-all” rule of sterile technique is to never allow a nonsterile item to contact any area of the patient that has suffered compromise of a natural barrier to infection. This rule is too general and too vague to be a practical guide, however, so we establish guidelines and rules for specific activities and specific items. You may have learned some of these rules in technical school, but we build on these rules and explain the rationale behind them in this lesson.

Sterile fields should be established and defined by sterile drapes

At first glance, anyone with surgical experience may think this rule states the obvious. However, many people do not consider the draping material they use to establish the field. For a field to be considered sterile *the drape must serve as a barrier*; it must prevent the microbes from the nonsterile areas beneath the drapes from migrating or passing through to the sterile areas above. This means the drape used to establish the field may vary, depending upon the intended application. For example, a sterile cloth sheet can serve as an effective sterile drape for a relatively dry procedure, but, the same sheet may allow "strike-through" in, and lose its barrier capabilities during, a procedure involving copious irrigation.

Sterile drapes should not only be placed on the patient, but also should be placed on all furniture and equipment that will be used or included in the sterile field. These drapes help isolate the field and prevent migration of contaminants from nonsterile areas. An example of this rule in practice is the draping of a single ring stand holding a basin. Even though only the inside of the basin must be sterile to contain the sterile solution, we generally drape the entire stand; then place the basin on it so the outside of the basin remains sterile as well. Draping the ring stand allows the stand to become part of the sterile field, reducing the risk that you'll contaminate yourself by accidentally touching the nonsterile area.

When handling, preparing, or placing sterile drapes, *handle them as little as possible*. Frequent handling of the drapes can cause air currents that disturb dust, lint, and microbes, possibly allowing them to migrate to the field. Handling the drapes also increases the risk of compromising the drapes' integrity. The more times you carry or move a drape, the more times you risk dropping it, dragging it across a nonsterile area, or snagging it on a sharp instrument and puncturing or tearing the fabric. Also; when handling or placing drapes, *protect your hands* from contamination by forming a "cuff" over them with the sterile drape fabric.

When draping, *keep the drapes compactly folded until you are ready to use them*. A folded drape is smaller and easier to handle than an open (or even partly open) one, and also creates less air movement as it is handled. You should also *hold the drapes higher than* the OR bed or furniture you are draping until you are ready to place it. This prevents you from contaminating the drapes by brushing against the nonsterile area. Once placed, drapes are considered *sterile at table level only*, so keep your hands and other sterile items above table level.

When draping the patient, *start by draping the operative site; then drape the peripheral areas*. This isolates the cleanest area first, and reduces chances of contamination from dragging drapes from nonsterile areas over the prepared surgical site. For this same reason, *once a drape is placed in position, it should not be moved*. Only after the patient is completely draped should you move your Mayo tray, back table, and other sterile-draped furniture you use to form the field.

A sterile field should be constantly monitored and maintained

After a sterile field is established, it should remain under the direct watch and guard of at least one staff member. This is one reason you *prepare or establish the sterile field as close as possible to the time of use*. Preparing the field too far in advance "ties-up" a surgery team member, making one less person available for other duties. There is no "magic" time limit on how long a sterile field remains sterile. However, another reason for preparing the field close to the time of use is that the more time a field is open and exposed to the environment, the greater the risk of contamination from airborne microbes. If the sterile field is established and the surgical procedure is delayed, *covering the sterile field is not allowed*. Since the field is considered sterile at table level only, and since most covers extend below table level, it is nearly impossible to remove a cover without contaminating the field. Also, covered surgical fields are often left unguarded or unwatched, which violates the next rule of sterile technique.

An unguarded or unwatched sterile field is considered contaminated. If a field is not continuously watched, contamination may occur during the time it is unobserved. A field may be contaminated by

a fly or other insect, or a piece of "fluff" may blow out of an air vent. To reduce the likelihood of unobserved contamination, *every surgical team member should be constantly alert for events that may result in contamination*. When contamination does occur, take corrective action as soon as possible.

When a sterile barrier, such as a drape or gown, is perforated, its integrity is compromised so it is considered contaminated. When you use tubing, wires, cables, cords, or other apparatus on the field, ensure you *use only non-perforating devices to attach them to the drapes*. Many drapes have built-in flaps or holes designed for attaching surgical accessories. If the drape you use has these holders, use them!

While punctures result in contamination from surfaces below the drapes, you must also guard against contamination from above. *All objects that enter or pass over a sterile field should be sterile or enclosed in a sterile drape*. You usually "drape-off" equipment such as X-ray machines, C-arms, or other nonsterile devices that must pass over the sterile field when you use them. You also use drapes to enclose nonsterile cameras and cords. Since all items used on the field must be sterile, *inspect all packaging and check the sterile integrity of all items before opening or delivering them to the sterile field*.

One of the most violated principles of maintaining a sterile field pertains to talking. Even though you wear a mask, when you talk, droplets are forcibly expelled through the material. These droplets become airborne, and they may result in contamination. For this reason, *talking should be kept to a minimum in the presence of sterile fields*.

All items used within or contacting a sterile field should be sterile

I know you are saying "Well DUH!!" However, while this principle sounds like common sense to anyone who has even a basic understanding of surgery, it must be stressed. A number of factors must be weighed before you can determine that an item is sterile. Some of these factors include:

- The type of packaging.
- The integrity of the packaging.
- The method(s) of sterilization.
- Acceptability of all sterilization indicators.
- How the item was stored.

Because the principles behind sterility are so critical, we cover many of these factors in-depth and individually in various areas throughout this volume, so we only touch on them here.

You should check every package you intend to open before you actually open it. Check the package integrity; if you see holes or tears in the wrapper, wet spots, or stains, consider the package contaminated because its integrity is violated. If an item was steam sterilized, but the tape used to seal the package was for gas sterilization, the item is not sterile. If an external sterilization indicator is suspect, such as an uneven color change on the chemically impregnated sealing tape, or if no indicator is present, the item is considered contaminated. If your facility uses expiration dates on its packages and the date has passed, the item is not considered sterile. Even though numerous safeguards and precautions are in place, it is possible for a non-sterilized item to wind up in the operating room. Be alert! Look for any discrepancy before and as you open the items, and, of course, do not use a suspect item. Translation: *When in doubt, throw it out!*

Methods for transferring items to a sterile field should maintain sterile integrity

Since all items used on a sterile field must be sterile, it stands to reason that they should be opened and transferred in a manner that keeps them sterile. We cover the methods and guidelines for opening sterile supplies more in-depth in the next section, but touch upon some basic principles now.

One of the first things you should do before transferring an item to the sterile field is check the external chemical indicator to ensure it has properly changed. If the color of the tape, dot, arrow, or other external indicator has not changed, the item is considered unsterile—toss it out! If the item is in a see-through package, check the internal chemical indicator as well.

To prevent contaminating the item by passing your unsterile arm over a stationary sterile wrapped item, *open the flap farthest away from you first, and open the flap closest to you last*. As you open the flaps, work by reaching under or around the object, never by reaching over the top of it. The *edges of a wrapper are considered contaminated*. As you open the wrapper flaps, firmly secure each open flap to keep it from "flipping" closed and contaminating the item you are opening. This also keeps loose flaps from contaminating the sterile field as you transfer the item. If you open and secure the flaps properly, the wrapper forms a barrier "mitten" between your hand and the sterile field. Also, to prevent contamination from air-borne microbes, do *not* wave the opened item around or walk around the room with it.

You should either *place opened sterile items securely on the field* or you should present them to the scrub tech. If you toss them onto the field, they may roll off the edge, or they may bump into other items and cause them to fall off the field. You should *also present sharp or heavy objects to the scrub tech, or open them on a separate sterile field*. Sharp and heavy items are likely to puncture the drapes, particularly if you "project" them onto the field. Heavy objects may also cause the drapes to slide, bringing a nonsterile area of the drape onto the sterile field. Sharp objects that are simply opened with routine supplies may be hidden among them, and may cause injury to the scrub tech or other sterile team member.

There are some special rules for dispensing sterile irrigating solutions in a manner that preserves sterile integrity. The rules are:

- *The solution receptacle on the sterile field should be placed as close as safely possible to the edge of the sterile field, or it should be held by the scrub technician, as the solution is poured.* This allows the circulator to pour the solution without reaching over the sterile field.
- *The solution should be poured slowly to avoid splashing.* Splashing solution can cause strike-through contamination of barriers that are not moisture-proof. A splashed solution may also contact a nonsterile area, then splash onto a sterile area; thereby contaminating the field.
- *Pour the bottle's entire contents into the sterile field container*. If you do not pour it all at once, discard the remaining solution. The outside of the bottle and the edge of the opening are considered unsterile. Drops of the solution contacting these areas may run back into the container, contaminating the remaining solution, if the bottle is tipped upright.

Figure 5–3 shows one method of dispensing solution. Notice the solution is poured into a round bowl inside the large basin. This reduces the likelihood of strike-through contamination from splashes, and, while not required, is a highly suggested technique. We cover dispensing and pouring of solutions more thoroughly in volume 5 of this course. We also cover specific techniques for opening individual specialty items as we discuss each item in the course. These basic guidelines should help you understand why we open sterile items the way we do, but it is important to follow local guidelines established for specific items used in your facility.

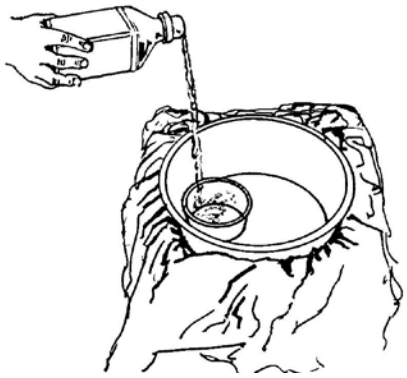

Figure 5–3. Dispensing solution into a sterile receptacle.

Sterile team members (scrubbed) should wear sterile gowns and gloves

The key word here is the second "sterile"—a *nonsterile gown does not* protect the patient. For your gown and gloves to be considered sterile, certain criteria must be met. Like drapes, they must serve as barriers to microorganisms. A gown or glove that permits bacteria to pass from nonsterile to sterile areas is not maintaining the integrity of the sterile field. Before donning the gown and gloves, you should perform a surgical scrub to reduce the number of bacteria on your hands and arms. When you "gown and glove" yourself, do so from a sterile field that is separate from the sterile field you will use during the procedure. Gowning and gloving from a separate sterile field reduces the risk of contaminating the entire set-up from an accidental break in technique.

You must also know the areas of the surgical gown that are considered sterile—and those that are not. The front of the gown is sterile from the chest to the level of the sterile field (usually the back table). Keep this in mind if you must work on a step-stool; remember to keep the area of your gown that was below the level of the back table away from the sterile field as you step onto the stool. The sleeves are sterile from about two inches above the elbows to the cuffs. The cuffs are considered unsterile *after* the gloves are donned. After you don your gloves, inspect them before you consider them as sterile. Obviously, a glove must have no holes or tears if it is to be a barrier to microbes.

Nonsterile areas of the gown include the neckline, shoulders, under-the-arms, and back. Why? The neckline and shoulders border the nonsterile areas of your head, neck, and mask. They are subject to contact contamination by these areas and also subject to moisture contamination from breathed air and perspiration. The underarms are subject to constant friction as you move your arms, which open them to the potential for perspiration strike-through. You also cannot keep your underarms in constant sight; this is also why the back of the gown is considered not sterile. Even though most gowns have a sterile "wrap-around" panel, the back of the gown is never considered sterile because you cannot see it.

Movement within or around a sterile field should maintain the integrity of the field

Excessive or careless movement of, or actions of, staff members can compromise the sterility of a field. To avoid this contamination, both the scrub and the circulator must be constantly aware of their movements and motions. Understanding some of the principles and guidelines pertaining to movement is essential for all individuals who work in the surgical arena.

As a circulator or other nonsterile team member, there are three simple rules to remember as you move around sterile fields (nonsterile personnel do not move within the fields).

1. *Always face the sterile field as you approach it.* By facing the sterile field and keeping it in constant view, you can prevent accidental contamination because you can see, anticipate, and prevent events likely to cause contamination.
2. *Do NOT walk between two sterile fields*. If you walk between two sterile fields, it is impossible to face them both and to keep both fields in view simultaneously.
3. *Always maintain a safe distance between yourself and the sterile field*. Since a sterile field is considered contaminated by any contact with a nonsterile item, you should keep nonsterile items away from the field. Current standards do not specify a defined distance, but your local policies may do so. A good "rule of thumb" is to try to stay at least one foot (12 inches) away from the sterile field.

As stated previously, all items used within or that pass over a sterile field should be sterile. This rule also applies to nonsterile personnel, so *do not reach over a sterile field*. Anytime you reach over a sterile area, bacteria sheds from your skin, hair, and clothes onto the sterile field, causing it to become contaminated. Pay particular attention to this as you open supplies or pour solutions.

When you are the "scrub" or other sterile team member, the principles and guidelines are more numerous and more complex. One of these principles is almost an exact opposite of the rule for circulators: *scrubbed personnel should remain close to the sterile field*. By staying close to the field

and not wandering around the room, you reduce the chances of accidental contamination. Another rule related to this principle is that, if movement is necessary, *scrubbed personnel should only move from one sterile area to another sterile area*. This means *scrubbed people should not leave the operating room.*

When scrubbed personnel must move or change positions, they *should move face-to-face or back-to back, keeping a safe distance between them*. This keeps either the sterile areas facing each other, or the nonsterile areas facing each other. The method you use depends partly on configuration of the sterile field. You should move in a manner to ensure you keep the field in view at all times. For example, if you need to change positions with the surgical assistant, moving from the patient's feet to the head:

- The assistant should remain facing the patient.
- You should turn around, facing the direction of your back table and stepping back away from the sterile field as you do so.
- You then side-step past the assistant, back-to-back, keeping some distance between you. Simultaneously, the assistant side-steps towards the patient's feet while facing the field.
- When you reach the desired location, you turn around, keeping as much of the sterile field in sight as possible, then step up to the patient.

Now wait a minute, you say! Didn't I turn my back on the sterile field as I faced back-to-back with the assistant? How did I keep the sterile field in sight?

You *are* unable to see the entire sterile field as you move like this, but, because the other sterile members are still facing it, they are watching the field; remember you are part of a sterile *team*. By backing away from the field then turning, you reduce the risk of contamination. If the assistant accidentally steps back and bumps your back, no contamination occurs (unsterile to unsterile). If you were passing while facing the assistant, you would be contaminated and have to change your sterile attire.

Another basic principle of sterile technique as it applies specifically to sterile team members is that they *should keep their hands and arms within the sterile areas*. This means *you do not reach below the level of the sterile field* as in "don't reach under the edge of the backtable to pull it up to the OR table." Yes, you know you see it all the time and it is up to you to correct the problem no matter who it is doing it. It also means that as you move around in the sterile field, you keep your hands in front of you (where you can see them), and not touch areas considered nonsterile.

How many of you have heard someone tell the scrub tech, "It's going to be awhile before we are ready for the case, have a seat until the surgeon comes in." Don't do it if you are the one scrubbed in, and don't let others do it either. Because areas below the level of the sterile field are not sterile, *sterile team members should avoid changing levels.* When you sit on a stool, all areas of your gown that drop below the level of the sterile field are considered contaminated. If you stand up after sitting, you bring these nonsterile areas back above the level of the field; thereby contaminating it. This means you should sit only if you will remain seated for the entire operation.

These principles and rules of sterile technique are the foundation upon which you must build your skills. Simply knowing these aseptic principles is not enough. You have to understand them thoroughly and must apply them appropriately. This text could never cover every situation you will come across, so you must master the knowledge of the basic principles so you can apply them to the various situations you experience. We now move to a subject you began in technical school, but one that is critical for you to understand—how we aseptically open sterile items.

228. How to open sterile supplies

Because all items used within a sterile field should be sterile, we must have some method of opening the packages without contaminating the item. While specific packages vary from facility to facility,

and new methods are being developed, most packaging falls under four basic types: rectangularly wrapped items, diagonally wrapped items, peel-pack items, and items enclosed in rigid sterilization containers.

Opening rectangularly wrapped items

Usually, you begin opening sterile supplies by starting with the procedure or drape pack which is placed in the center of the back table. This pack is usually wrapped rectangularly, but it may be wrapped rectangularly in two different ways. It may be wrapped so the folds of the narrow edge have to be opened first, or the folds of the long edge may have to be opened first. The way it is wrapped determines how it is placed and opened on the back table. When the pack is opened on the table, the material it is wrapped in becomes the drape for, and consequently the sterile field definer for, the back table. This means it is crucial that the pack is placed and opened properly.

Starting with the narrow edge

The numbered steps below describe how to open a drape pack that requires you to open the folded narrow edge first. Many commercial manufacturers use this method to wrap drape packs; it is seldom used for local processing. Packages wrapped in this manner often have directions for placing and opening the pack printed on the outside of the wrapper. Most open as described below.

1. Center the pack with the seam formed by the folds *parallel to the long edge* of the table. The first flap should open away from the center of the room.
2. Step to the side to keep from reaching over the sterile surface created as the fold is opened. Then open the first fold.
3. Be careful not to touch or reach over the sterile area exposed by the first flap. Open the second fold in the same way as the first, from the side of the table.
4. Next, reach out with both hands and grasp the edge of the folded cuff. Your hands should be spread apart about the same distance as the table is wide.
5. Now lift slightly and slide the drape open by dragging it towards your body, stepping back to keep your distance from the sterile drape as you open it.
6. To open the final fold, walk around the table to the opposite side; remember to keep facing and watching the sterile field as you do so.
7. Open the last fold in the same manner as you opened the third.

Starting with the long edge

Opening a drape pack that is wrapped so that the long flaps of the drape must be opened first requires a slightly different technique. Some commercial manufacturers use this method of wrapping, and it is the rectangular wrapping method most often used for items sterilized in the hospital. The steps involved in opening a pack that is wrapped in this way are listed below.

1. Center the pack with the seam formed by the folds *perpendicular to the long edge* of the table.
2. The first flap should open away from the center of the room. As opposed to opening a pack with the narrow folds first, to open a long fold you stand in front of the table.
3. Shift your position, moving slightly to the left when opening the left flap, to the right when opening the right flap.

   NOTE: Many packs that are wrapped in this manner have folded cuffs so you can grasp the edges of the wrapper while opening it. When you open a long flap without a cuff, use one hand to grasp the flap in the center of the pack, near the wrapper edge.
4. Use the left hand to open the left flap, and the right hand to open the right flap.
5. Lift the flap slightly off the pack, then slide or “peel” it open. You are now ready to open the long folds of the pack.

6. If the first long flap opens in the opposite direction from where you are standing, walk completely around the table to avoid reaching over the sterile field.
7. Spread your arms to about the same distance as the table is wide, or as wide as you can without leaning over the table.
8. Grasp the edge of the cuff, being careful not to touch or otherwise contaminate the opposite flap, and peel the fold open.
9. Walk around the table and repeat the procedure to open the final fold.

Regardless of the method used to wrap and, therefore, open the pack, you should keep the following guidelines in mind:

- When opening the long flaps, extend your arms as far as you can towards the sides of the table without leaning over the table.
- Peel back the flaps rather than lifting them open. This reduces the chances of bringing an unsterile area up to the sterile field, reduces air currents that can stir up microbes, and keeps the drape fabric from "bunching" at the corners.
- When moving around the various tables and stands to position yourself for opening the different wrapper flaps, always face the field. Keep your hands and arms down by your sides so you don't accidentally touch or reach over a sterile area.

The other method we use to wrap supplies is the diagonal wrap. The procedures for opening them are similar to the rectangular wrap for large, stationary items, but slightly different for hand-held items.

Opening diagonally wrapped items

Opening large, stationary diagonally wrapped items is similar to opening rectangularly wrapped ones; the same basic dos and don'ts apply. The steps for opening the wrapper of a *stationary*, diagonally wrapped item are described below.

1. Position the package so the first flap opens toward the walls, away from the center of the room.
2. When opening the first flap, stand to one side of the package to prevent reaching over the sterile field.
3. Move to the front of the pack (your back facing the center of the room) and open the second and third wrapper flaps to the sides.
4. Open the flaps by moving your hand in an arc, rotating the flap from the center of the package, out towards the opened first flap (do not reach over the opened area), and out towards the sides.
5. Hold on to the third flap as you peel back the fourth and last flap. This helps prevent bunching of the wrapper at the corners.

Hand-held diagonally wrapped items are opened using a slightly different procedure. The wrappers are opened in the same sequence as, and in the same direction as, the wrappers of a stationary item. The difference is that the corner of each flap is held and secured as it is opened. Securing the flaps prevents the contaminated edges from brushing against the sterile field and also prevents the wrapper from contaminating the contents by springing closed if the wrapper fabric has any memory characteristics. Securing the folds also reduces air currents produced by the "fanning" action of the wrappers. The steps to opening a *hand-held*, diagonally wrapped item are:

1. Turn the package so the first flap opens to the side. This is so you don't cross over the top of the sterile field when opening the first flap.
2. After you open the first flap, turn the package again so the second and third flaps can be opened to the sides.
3. Open each side flap, taking care to avoid reaching over the sterile item or sterile field.

4. After you open the fourth flap, reach under the item and grasp the corners of the four flaps. Pull them back over your forearm to form a kind of sterile "mitten" over your hand. This mitten serves as a barrier to prevent you from contaminating the sterile team member or sterile field as you introduce the item.

Exactly how you introduce the item to the sterile filed is determined by local policy. In technical school, you learned to "project" some items onto the field, and to hand other items to the scrub technician. Some facilities consider the "mitten" you form with the wrapper flap to be an acceptable enough barrier to allow you to place the item directly onto the sterile field. As always, follow the policies of the facility in which you are working.

Opening peel-packs

Small lightweight items are often placed in envelope-like packages commonly called *peel-packs*. Opening these items is our next topic.

We routinely open items packaged in paper back/plastic front, all paper, or all plastic peel-packs. These usually contain small, hand-held items such as suture, gloves, sponges, and individually wrapped instruments. Grasp the flaps on a peel-pack to prevent contaminating the contents as the flaps are peeled back. The unsterile team member should touch only the outer edges of the package flap, and the sterile member should touch only the inside contents as far as possible away from the unsterile member. This method works well for items that are the size of suture packages or larger. If the item is smaller than a suture package, the scrub should use a sterile instrument, such as a hemostat, to grasp the item. The scrub should always use an instrument to receive a sharp object, such as a knife blade, as it is being opened. After the scrub has a firm grasp on the opened object, the unsterile member should peel back the remaining packaging.

When "projecting" peel-pack items onto the sterile field, you must remember that the edges of the package are not sterile. *Do not* let the package contents slide over or otherwise contact these edges. If a peel-pack tears as you are opening it, it is almost impossible to continue to open the package and maintain sterility of the contents. Consider the item unsterile, and discard or reprocess it. Remember, "when in doubt, toss it out" is the rule of sterility—there is no compromise.

You need to remember two additional points as you "project" items onto the sterile field. The first is that, as stated in the general sterile principles, *place opened sterile items securely on the field.* In simple terms, make sure whatever item you are opening will stay on the sterile field once it is open. Ensuring the items are secure on the field is not difficult if you apply a little forethought. Open small "bouncy" items into a basin; the sides secure it on the field. Open a lightweight square or flat item, such as sterile gloves in their package, on an uncluttered, flat surface. Hand heavy or awkward items directly to the scrub technician.

The second point is repetitive, but is important enough to warrant the additional emphasis; never "project" sharps such as unguarded needles and scalpel blades onto the sterile field. This is a dangerous practice that can not only result in compromise of the sterile field by puncturing the barriers, but may also result in injury to the scrub technician as he or she prepares the sterile items. A secondary reason for not opening these small sharps onto the field is because they are usually counted items. Handing blades and needles directly to the scrub technician ensures both the scrub and circulator know exactly what counted items are open and where they are. Many facilities have adopted policies that specify all counted items be handed directly from circulator to scrub, and then counted immediately to reduce chances of any discrepancy.

Opening rigid containers

In addition to wrapped items and peel-pack items, we use various rigid containers to hold our sterile items. The techniques used to open these are completely different from the other packaging methods we have covered thus far. There are so many types and manufacturers of rigid sterilization containers

that it is not practical to list the exact procedures for opening each type. As always, follow the specific manufacture's recommendations, and local policy, for the containers used in your facility.

While we cannot cover the specific procedures for each container, most containers are similar in structure, and they open in a similar fashion. The general steps to opening a rigid container are:

1. The circulator checks the external chemical indicator(s) to ensure the container has been subjected to the sterilization process. If the indicators are acceptable, the circulator then checks the integrity of all the containers seals and safeguards.
2. The circulator unfastens the top of the container by breaking the seals and loosening the locking mechanism used. The locking mechanism often consists of "buckle-like" latches on the sides of the container, but varies from manufacturer to manufacturer, and even by individual type of container.
3. The circulator then removes (or opens) the lid, touching only the external surface. This usually involves lifting straight up, and then tilting the lid backwards towards the circulator's body. If the container has a hinged lid, it should be opened in a manner that prevents the circulator from reaching over the sterile contents. This usually means the hinged-side of the container faces the circulator.
4. The scrub technician lifts the inner tray straight up and out of the container, using the internal handles. The scrub must be careful to touch only the inside tray, and must be careful not to allow the inner tray to touch the top edge or outside walls of the outer container.

Some containers have a wrapped tray or trays inside the outer sterilization container. If this type of system is used, the wrappers are generally considered as part of the sterile contents and they are opened by the scrub. Some containers are also designed for high-speed sterilization (not to be confused with "flash" sterilization). These trays vary greatly in design and use. Because the design of rigid containers varies so greatly from manufacturer to manufacturer, and even from container to container, it is absolutely imperative that you follow the manufacturer's instructions and the locally established policies for their use.

You should now have a pretty thorough working knowledge of sterile technique and aseptic principles. These principles and rules are the foundation upon which you must build your skills. This knowledge, coupled with a strong surgical conscience, will help ensure you use only sterile instruments and supplies, and help you provide the highest quality surgical care to our patients. Simply knowing these aseptic principles is not enough. You have to understand them thoroughly and must apply them without fail. This text could never cover every situation you will come across, so you must master the knowledge of the basic principles, and apply this knowledge to the various situations you experience. Remember, there is no compromise to sterility; an item is either sterile or not sterile—when in doubt, toss it out!

Summary

This brings you to the end of this unit, and this volume. The volume began with a "primer" course in microbiology, the infectious process. We then learned about basic infection control guidelines and how to prepare ourselves and the surgical environment for surgical procedures. Instrument and supply processing were covered next as we walked an instrument set through the steps involved from its reception in the decontamination area, through the cleaning and assembly process, and to the final preparation for sterilization. The next unit covered the difference between disinfection and sterilization and described various sterilization methods, including steam sterilization and some methods of chemical sterilization. This final unit closely examined how to monitor and maintain sterility as we prepare to begin the actual surgical procedure.

It is absolutely essential that you have an in-depth understanding of the subjects covered in this volume. Remember, infection control is everybody's responsibility. How would you want your surgical care providers to perform?

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

227. Principles and rules of sterile technique

1. What is meant by “a drape must serve as a barrier”?

2. When draping, what should you do to reduce causing air currents that disturb dust, lint, and microbes, possibly allowing them to migrate to the field?

3. Once placed, what levels of a drape are considered sterile?

4. When draping the patient, where should draping start?

5. List some reasons you should prepare or establish the sterile field as close as possible to the time of use.

6. Why is an unguarded or unwatched sterile field considered contaminated?

7. Why do we inspect all packaging and check the sterile integrity of all items before opening or delivering them to the sterile field?

8. When opening a wrapped item, why should you open the flap closest to you last?

9. How should you open sharp or heavy objects?

10. What areas of a sterile gown are considered sterile?

11. What areas of a sterile gown are considered nonsterile?

12. When scrubbed personnel must move or change positions, how should they do so?

228. How to open sterile supplies

1. List the four basic packaging methods that you need to know how to open.

2. What are the two variations in the way a rectangularly wrapped procedure or drape pack is opened?

3. Why are wrapper flaps peeled back and not lifted?

4. Describe how you open a stationary, diagonally wrapped item.

5. How should the scrub grasp a peel-packed item that is smaller than a suture package?

6. What are the most important things to remember when opening and projecting peel-packed items?

7. Describe how a scrub technician should remove the sterile contents from a rigid container.

Answers to Self-Test Questions

223

1. Thermometers, gauges, timers, recording devices.
2. It measures the internal temperature of the exhaust line of the sterilizer, which is theoretically the temperature of the coolest area inside the sterilizer chamber. It is located in the exhaust line of the sterilizer.
3. The jacket pressure and the chamber pressure. Some sterilizers also use a temperature gauge as one of the devices used to report the sterilizer chamber temperature registered by the internal thermometer.
4. Daily, usually in the morning before cleaning the sterilizer.
5. Sterilizer number, the date, the time, and the load or lot control number. Most local policies also require the operator's name.
6. To provide hospital personnel a visual method of determining whether items have been subjected to a sterilization process.
7. In an area most difficult for the sterilant to reach, usually the geometric center of the package.
8. That a sterilization failure has occurred and the items in the package are unsterile.
9. (a) A Bowie-Dick or air removal test. (b) It tests for complete removal of air from the sterilizer chamber during the pre-vacuum phase. (c) Fold laundered linen hand towels to about 9 × 12 inches making a stack 10 or 11 inches high. Place a commercially manufactured Bowie-Dick test sheet, or a locally made test sheet, in the middle of the stacked towels. Wrap the towels (with positioned indicator sheet) in a single wrapper, loosely applied.

10. (a) Horizontally at the bottom front of an empty prevacuum sterilizer chamber, directly above the drain strainer. (b)The sterilizer controls are set for a 3.5 minute exposure time, if possible, at 273 °F (133 °C). A standard cycle may be run, or the dry cycle may be omitted to save time. The actual exposure time period should never exceed four minutes.
11. Testing with biological indicators.
12. *Bacillus stearothermophilus*.
13. A biological indicator that is not subjected to a sterilization process, but is incubated along with the test pack biological indicators to prove viability of the spores and proper function of the incubator.
14. At least weekly, preferably daily.

224

1. At the bottom front of a fully loaded sterilizer rack or cart, just above the chamber drain.
2. The sterilizer is re-tested with another biological test pack immediately. If second indicator is positive, the sterilizer is removed from service, medical maintenance is notified, and a recall of all supplies run in the sterilizer is implemented. If maintenance checks indicate the sterilizer is functioning properly, then supply processing, wrapping, loading, and operating techniques are reviewed and revised as needed.
3. Any six of the following: (1) Date of test, (2) sterilizer number, (3) load contents, (4) sterilization cycle number, (5) sterilization conditions, (6) results of biological control indicator, (7) results of biological test indicator, (8) chemical indicators from each test pack (including air removal test sheets), (9) completed recording charts or computer printouts, (10) name of sterilizer operator.

225

1. Moisture strike through, dirt or dust forced through package pores, package damage.
2. Handle them as little as possible between sterilization and use.
3. Immediately after sterilization, when putting the item in storage, when removing the item from storage, and just before use.
4. It is discarded if disposable and reprocessed if reusable; because the item is considered contaminated by dirt and microbes forced into the package by the impact of the fall.
5. To minimize traffic through the area and help reduce the number of potentially contaminating incidents and excessive air movement that transports airborne contaminants from other areas.
6. A positive-pressure ventilation system with at least four air exchanges per hour.
7. The temperature should be kept between 68 and 73 °F and the humidity no greater than 70 percent.
8. They harbor dust, microorganisms, molds, fungi, and insects.
9. 8 inches above the floor, 18 inches below the ceiling, and 2 inches from outside walls.
10. Keep the doors closed.
11. Weekly.

226

1. At least weekly.
2. The packaging method, stock level, or stock rotation may need adjusting.
3. Those with drugs (like anesthesia block trays), culture media (as in culture tubes), or other chemical agents (like the chemicals in some blood collection tubes).
4. First in, first out. The items placed in storage first should be used first.
5. Shelf life is the length of time a sterile item is assumed to remain sterile while in storage.
6. The packaging used, the number of times a package is handled—and number of people handling it—between sterilization and use, the storage method used, and other factors.
7. (1) How permeable or porous the package is.
   (2) How long (under various conditions) the packaging retains its barrier capability.
   (3) What length of time the manufacturer states the items packaged in their product can be considered sterile.
   (4) The sealing method used also affects shelf life.

8. The more times an item is handled, or the greater the number of people handling it, the greater the risk of contamination of the contents. Handling of sterile items may force unsterile air into a package, or it may result in "strike-through" from moisture on the hands, enabling airborne contaminants to enter the pack and compromise sterility.
9. Packages wrapped in impervious materials such as plastic.
10. (1) Label each item with the identity of the contents and a load control or other traceability label.
    (2) An external chemical indicator must be on the outside of each item.
    (3) The integrity of each package must be inspected before it is placed in storage and again before use.
11. It involves labeling each item sterilized with a specific expiration date.
12. Any six of the following:
    (1) Biological monitoring should be accomplished at least once a week.
    (2) Every item considered sterile indefinitely must have an exterior label indicating that the "contents are sterile unless the package is opened or damaged" or similar statement.
    (3) Designation of indefinite shelf life does **not** apply to items wrapped in cloth or disposable wrappers unless they are placed in dust covers within a few hours after sterilization.
    (4) Items in peel-packs are considered sterile indefinitely.
    (5) Items wrapped in cloth or disposable wrappers, then placed in plastic dust covers within a few hours after sterilization are considered sterile indefinitely.
    (6) Items in rigid containers are sterile for as long as the manufacturer recommends. If no recommendation is given, indefinite shelf life may be assumed as long as the filters remain in place, sealing valves/gaskets remain sealed, and the container securing devices/safety seals are intact.
    (7) All items in compromised packages (damaged, torn, dirty, dusty, damp, and stained) are *not considered sterile.* Return them for reprocessing.
    (8) Practice stock rotation in all areas of the medical facility to ensure that items sterilized first are used first (remember FIFO).
    (9) Facility-wide education and training must be provided on the labeling system used, on the proper handling and visual inspection of packages, stock rotation procedures, and use of items in dust covers.

227

1. It must prevent the microbes from the nonsterile areas beneath the drapes from migrating or passing through to the sterile areas above.
2. Handle drapes as little as possible.
3. Table level only.
4. At the operative site.
5. After a sterile field is established, it should remain under the direct watch and guard of at least one staff member. Preparing the field too far in advance "ties-up" a surgery team member, making one less person available for other duties. The more time a field is open and exposed to the environment, the greater the risk of contamination from airborne microbes.
6. Contamination may occur during the time it is unobserved.
7. All items used within a sterile field must be sterile.
8. To prevent contaminating the item by passing your unsterile arm over the sterile wrapped item.
9. Present sharp or heavy objects to the scrub tech, or open them on a separate sterile field.
10. The front of the gown is sterile from the chest to the level of the sterile field (usually the back table). The sleeves are sterile from about two inches above the elbows to the cuffs.
11. The neckline, shoulders, under-the-arms, back, and any area that falls below table level. The cuffs are considered unsterile after the gloves are donned.
12. They should move face-to-face or back-to back, keeping a safe distance between them.

228

1. Rectangularly wrapped items, diagonally wrapped items, peel-pack items, and items enclosed in rigid sterilization containers.

2. The folds of the narrow edge may have to be opened first, or the folds of the long edge may have to be opened first.
3. This reduces the chances of bringing an unsterile area up to the sterile field, reduces air currents that can stir up microbes, and keeps the drape fabric from “bunching” at the corners.
4. (1) Position the package so the first flap opens away from the center of the room.
   (2) When opening the first flap, stand to one side of the package to prevent reaching over the sterile field.
   (3) Move to the front of the pack (your back facing the center of the room) and open the second and third wrapper flaps to the sides.
   (4) Open the flaps by moving your hand in an arc, rotating the flap from the center of the package, out towards the opened first flap (do not reach over the opened area), and towards the sides.
   (5) Hold on to the third flap as you peel back the fourth and last flap.
5. By using a hemostat or other instrument.
6. The edges of the package are considered unsterile and you should not let contents slide over or cross the edges. Make sure whatever item you are opening will stay on the sterile field once it is open. Never “project” sharps such as unguarded needles and scalpel blades onto the sterile field.
7. The scrub technician lifts the inner tray straight up and out of the container, using the internal handles. The scrub must be careful to touch only the inside tray, and must be careful not to allow the inner tray to touch the top edge or outside walls of the outer container.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field Scoring Answer Sheet.

Do not return your answer sheet to AFCDA.

79. (223) What does the sterilizer tape used to seal the outside of wrapped packages indicate by changing color?
    a. The package is sterile.
    b. The sterilizer is functioning properly.
    c. The package has been wrapped properly.
    d. The package has been subjected to a sterilization process.

80. (223) In what type of sterilizer and at what time is an air removal (Bowie-Dick) test pack run?
    a. Prevacuum sterilizer; with the first full load of the day.
    b. Prevacuum sterilizer; before the first full load of the day.
    c. Gravity-displacement sterilizer; with the first full load of the day.
    d. Gravity-displacement sterilizer; before the first full load of the day.

81. (224) Where should you place a biological test pack in a steam sterilization load?
    a. In the upper back, just below the steam inlet.
    b. In the bottom front, just above the steam inlet.
    c. In the upper back, just below the chamber drain.
    d. In the bottom front, just above the chamber drain.

82. (224) What is the *first* action taken if results of biological testing show bacterial growth?
    a. Call medical maintenance.
    b. Take the sterilizer out of service.
    c. Run a second test pack immediately.
    d. Recall all items sterilized in the faulty sterilizer.

83. (225) What *basic* rule do you follow when handling sterile packaged items?
    a. Hand-carry supplies close to your body, cradled in your arms.
    b. Wear sterile gloves anytime you are handling wrapped sterile supplies.
    c. Handle supplies as little as possible between the time of sterilization and use.
    d. Never let sterile supplies be handled by the same person twice following sterilization.

84. (225) If a reusable sterile peel-packed item falls or is dropped on the floor, it may
    a. not be used unless you saw it fall.
    b. not be used unless it is reprocessed.
    c. be used if it landed plastic side down.
    d. be used if picked up, the packaging is still intact.

85. (225) What type of storage is *preferred* for storage of sterile items?
    a. Storage bins.
    b. Supply carts.
    c. Open shelves.
    d. Closed cabinets.

86. (226) Which of the manufacturer sterilized (pre-packaged) supplies is most likely to have an expiration date?
    a. Drape packs.
    b. Culture tubes.
    c. Knife (scalpel) blades.
    d. Electrosurgical handpieces.

87. (226) Which statement *best* describes the phrase, “first in, first out”?
    a. Items put in storage first are used first.
    b. Newly sterilized items are put on the shelf in front of older items.
    c. Supplies are rotated so items with no expiration date are used first.
    d. Items that have reached or gone past their expiration date are the first ones used.

88. (226) Shelf life is *best* described as
    a. the total life cycle of a reusable item from cleaning to use.
    b. the actual amount of time that passes between sterilization and use.
    c. the length of time a sterile item is assumed to remain sterile while in storage.
    d. the length of time that shelving material and storage devices should maintain their usefulness.

89. (226) Using the event-related method of shelf life, biological testing of steam sterilizers must be done at *least*
    a. daily.
    b. weekly.
    c. monthly.
    d. in every load.

90. (227) Why should sterile drapes be placed on all furniture and equipment used or included in the sterile field?
    a. They provide a barrier for dust and lint.
    b. They identify the sterile integrity of all items in the sterile field.
    c. They prevent the migration of contaminants from nonsterile areas.
    d. They provide easy identification of equipment to be used in the procedure.

91. (227) When working in a sterile field and opening a sterile wrapped item, why should you open the flap farthest from you first?
    a. It allows you to prevent the flaps from contaminating the sterile field.
    b. It prevents contamination by your unsterile arm passing over the open package.
    c. It enables the checking of the external chemical indicator.
    d. It allows the flaps to be secured preventing contamination.

92. (227) To ensure that all items used on the sterile field are sterile, the circulator routinely checks each wrapped package *before* it is opened for all of the following *except*
    a. integrity of the package.
    b. date the sterility expires (if applicable).
    c. condition of the internal chemical indicator.
    d. condition of the external chemical indicator.

93. (227) When opening sterile supplies, the edges of a wrapper are considered
    a. sterile.
    b. unsterile.
    c. semi-sterile.
    d. surgically clean.

94. (227) Which situation represents the correct application of aseptic principles for using solutions?
    a. The circulator opens the container, discards the cap; then pours all of the solution into a sterile basin.
    b. The circulator uses the remainder of a saline solution previously opened to fill a sterile glove rinsing basin.
    c. The circulator opens the container, pours half of the solution, and replaces the cap to keep the solution sterile for later use.
    d. The circulator opens the container, pours half of the solution, and *does not* replace the cap to keep the solution sterile for later use.

95. (227) Which of the following is considered a break in aseptic technique?
    a. A circulator passes a sterile field while facing it.
    b. A sterile surgical team member passes close to a sterile area with his or her back towards it.
    c. After opening a muslin wrapped item, the circulator carefully drops the wrapper in the linen hamper.
    d. The sterile scrub specialist and surgeon trade places at the side of the operating table by passing each other back-to-back.

96. (228) To aseptically open a stationary, diagonally-wrapped item, the packaged is positioned so the first flap opens towards the
    a. circulator's left.
    b. circulator's right.
    c. walls of the room.
    d. center of the room.

97. (228) Why is the way sterile packages are placed on the back table important?
    a. Instruments have to be in easy reach.
    b. The sterile wrapping material becomes the sterile field.
    c. Prevents the empty pack from contaminating the sterile field.
    d. Allows the empty pack to be easily removed from the sterile field.

98. (228) Why should you discard or reprocess an item if the peel-pack tears when it is being opened?
    a. Impossible to maintain sterility of the contents.
    b. Impossible to safely remove instruments.
    c. The item can still be used if it is quickly removed.
    d. Sharp instruments cannot be safely removed.

99. (228) What is the *most* important thing for a circulator to keep in mind when opening peel-packaged items?
    a. Peel-packs are not very strong and the seals could separate at any time.
    b. The flaps should be grasped very loosely to prevent tearing the package body.
    c. The package contents should not slide over or otherwise contact the package edges.
    d. If a peel pack tears during opening, extra care must be taken to project the contents on the field.

100. (228) When opening a rigid sterilization container, the scrub technician should
    a. break the seals and unfasten the top locking mechanism.
    b. use the internal handles to lift the tray straight up and out of the container.
    c. use the external handles to carry and position the container on the back table.
    d. remove the lid by lifting straight up, then tilting the lid backwards towards his or her body.

Student Notes

Glossary

Terms

antibodies Protein-containing substances produced by the body's immune system that attack specific foreign substances (antigens) that enter the body.

antigens Used to describe any foreign substances entering the body that trigger the immune system to produce antibodies.

antiseptic Any chemical agent used to disinfect body surfaces without causing harm to tissue cells. Not as strong as the chemical disinfectant agents used to decontaminate environmental surfaces and other inanimate objects.

asepsis The condition of being without infection or microbial contamination. The term is frequently used to describe procedures that maintain this state.

autotrophs Bacteria that live on carbon derived from carbon dioxide generated by an inorganic source.

bacilli Rod-shaped bacterial cells.

bacillus stearothermophilus A heat-resistant, spore-forming bacteria commonly used in test ampules and strips to monitor the effectiveness of steam sterilizers.

bacillus subtilis A resistant, spore-forming bacteria commonly used in test ampules and strips used to monitor the efficiency of ethylene oxide sterilizers.

bacteria Single-celled microorganisms that are members of the plant family.

bactericidal Capable of destroying bacteria.

bioburden The quantity and type of microorganisms in or on a specified location.

Bowie-Dick Test A test using specially designed chemical indicators to test the air removal effectiveness of prevacuum steam sterilizers.

cavitation The process by which tiny bubbles, created by high-frequency sound waves generated in an ultrasonic cleaner, clean soil from the surfaces of surgical instruments. The tiny bubbles implode, dislodging soil from the instruments.

cilia Tiny hair-like projections on the surfaces of certain mucous membranes that filter and trap foreign bodies, keeping them from entering more infection-susceptible tissues.

circulator A surgical nurse or technician who performs non-sterile duties in support of the sterile surgical team during an operation.

cleaning Physical removal of organic material or soil from an object through the use of water, with or without detergents.

clostridial myonecrosis The destruction of muscle tissue caused by powerful toxins and enzymes secreted by the spore-forming bacteria *Clostridium perfringens (welchii.)* This process is commonly called gas gangrene.

cocci Round-shaped bacterial cells.

contamination A condition in which living microorganisms are present, or the introduction of living microorganisms into a previously sterile environment.

cross-contamination Transmitting potential pathogens from one individual or object to another.

cystoscope A lighted, lensed instrument used to visualize the urinary bladder and urethra.

cystoscopy	A visual examination of the urinary bladder using a lighted, lensed instrument (cystoscope) inserted through the urethra.
decontamination	Any process used to render a contaminated object biologically safe for handling by personnel without wearing personal protective attire; removal of contaminants and reduction of bioburden.
dermatome	An extremely sharp surgical instrument used to remove thin layers of skin from a patient's body for the purpose of skin grafting.
detergent-germicide	Any chemical disinfectant agent combined with a detergent; used for cleaning and disinfecting surfaces in patient care areas.
disinfectant	Any chemical agent that rapidly destroys microorganisms. The term is usually applied to agents used to decontaminate inanimate objects and environmental surfaces.
disinfection	The process of removing, destroying, or controlling the growth of all but the most resistant types of microorganisms (such as bacterial spores or certain viruses) on inanimate materials or body surfaces.
dormant bacteria	Bacterial cells that are in an inactive, non-reproducing state (bacterial spores).
edema	Swelling caused by an abnormal build-up of fluid in injured or infected tissues.
enteric bacilli	Various types of anaerobic, rod-shaped bacteria, commonly found in the intestinal tracts of humans and animals.
facultative anaerobes	Bacteria that can grow either in an atmosphere containing oxygen or one without oxygen.
final sterilization	The sterilization of an item enabling the item to be stored or used on a patient.
final sterilization	The sterilization of patient care items after they have been terminally sterilized and thoroughly cleaned to prepare them for reuse on other patients. Most items are packaged prior to final sterilization, but some may be un-packaged and "flash" sterilized as they are needed.
fomite	Any inanimate object or substance capable of harboring and transmitting a disease.
germicide	A process or agent that kills germs (microorganisms).
gram stain	A laboratory technique used to classify bacteria; it involves using a purple-colored dye to stain bacteria. Bacteria that absorb the dye are called *gram-positive*; those that do not are called *gram-negative*.
heterotrophs	Bacteria that survive on nutrients obtained from organic sources of carbon, such as proteins, fats, and sugars.
instrument milk	A non-oily, non-silicone-based, water-soluble surgical instrument lubricant.
leukocytes	General term used to describe all types of white blood cells.
localized infection	An infection confined to the area immediately surrounding an injury or pathogen entry site, often characterized by the formation of pus-filled boils, abscesses, or pustules.
lumen	The channel within a hollow, tube-shaped instrument, needle, or body structure.

lymphocytes	Large white blood cells, produced mainly in lymphatic tissue, which attack, engulf, and destroy invading microorganisms.
morphology	The study of the internal and external shape and arrangements of organisms in order to classify them.
necrotic	Dead, dying, or decaying (tissue).
normal flora	A general term used to describe populations of bacteria that normally inhabit certain areas of the body.
nosocomial infections	Infections that originate as a result of a patient's hospitalization (hospital acquired infections).
obligate aerobes	Bacteria that only grow in an oxygen-containing atmosphere. Also known as "strict" aerobes.
obligate anaerobes	Bacteria that only grow in an atmosphere devoid of oxygen. Also known as "strict" anaerobes.
optimum temperature	The temperature at which a given bacteria grows best.
parasite	Any organism that lives on or within another living organism and relies wholly or in part on that living host organism to sustain its existence.
pathogenic	Capable of producing disease.
pH	The symbol relating the hydrogen ion (H) concentration of a solution to a standard solution. A measure of the solution's acidity or alkalinity. A pH of 7 is considered neutral; above 7 is alkaline, below 7 is acidic.
positive pressure	When referring to ventilation or air handling systems, describes a condition where the atmosphere in a room is higher than in the surrounding rooms. Its "blows" microbes out of an area when a door is opened.
purulent	Pus-containing or caused by pus.
pus	An accumulation of live and dead organisms, dead leukocytes, and tissue fluid, that combines to form a thick, white-colored substance as a result of the body's response to infection.
regional infection	An infection that spreads via the lymphatic system to regional lymph glands and nodes causing painful swelling of the nodes and glands.
resident microorganisms	Microorganisms that normally live in the deep cracks and folds of the skin or in body orifices.
retrograde contamination	Bacterial contamination of a sterile package caused when moisture penetrates the package material allowing bacteria to "wick" into the pack. It is more commonly known as "strike-through."
saphrocyte	An organism that lives off dead or decaying organisms.
saturated steam	Steam that is "almost wet;" it contains the maximum amount of water vapor that quickly releases its heat during a steam sterilization cycle.
scrub	A surgical technician (or nurse) who performs sterile duties in direct support of the surgeon and other sterile surgical team members. The term is also commonly used to refer to the process of rendering skin surgically clean by the use of antiseptics.
septic	Grossly contaminated with microorganisms.

septicemia	Chronic systemic infection with gross continual circulation of pathogenic microorganisms in the blood stream and throughout the body. Commonly referred to as "blood poisoning."
spirilla	Spiral-shaped bacterial cells.
spores	Inactive, round, dry, thick-walled bodies found within certain bacterial cells that contain genetic material capable of developing into a vegetative bacterial cell when favorable conditions exist. Spores are the dormant state of certain bacteria and are extremely resistant to destruction.
sterilant	Any sterilizing agent, such as the steam-under-pressure or ethylene oxide commonly used in hospitals.
sterile	Completely free from all living microorganisms, including bacterial spores and viruses.
sterilization	*Absolute definition*- A process that destroys all living microorganisms, including bacterial spores and viruses. *Technically correct definition*- a process that provides the highest level of assurance that an item can be expected to be free of viable microorganisms.
strike through	See retrograde contamination.
superheating	A condition that results when dehydrated, unlaundered fabrics are repeatedly steam sterilized. The temperature of the fabric absorbs and releases more heat than is in the surrounding steam. This results in fabric deterioration.
suppurative infection	An infection that forms pus.
surgically clean	The term used to describe the condition of the skin after it has been thoroughly washed and exposed to an antiseptic. This results in a significant reduction in resident and transient bacteria content. The term is also sometimes used to refer to items that have been high-level disinfected.
systemic infection	An infection that has spread beyond the lymphatic system and into the circulatory system; infection is spread throughout the body.
terminal sterilization	Sterilization of contaminated patient care items as part of the cleaning and decontamination process. Its purpose is to reduce risk of cross-contamination between patients and personnel by rendering a previously contaminated item biologically safe for handling by processing personnel. Terminal sterilization is not an end process.
thermal death point	The point at which the combination of temperature and exposure time destroys all microorganisms.
tuberculocidal	An agent or process that kills the bacteria mycobacterium tuberculosis.
vegetative bacteria	Bacteria that are in an active growth state.
virucidal	An agent or process that kills viruses.
virulent	Highly infectious, contagious, and pathogenic.
viruses	Extremely tiny microorganisms that can only be seen with an electron microscope and are capable of passing through bacterial filters. Viruses are pathogenic parasites that can only grow and multiply within living cells.
washer-decontaminator	A machine that washes contaminated instruments, then subjects them to a disinfection process to render them biologically safe for processing personnel to handle.

washer-sterilizer A type of steam sterilizer that has a cycle to wash contents, then sterilize them. It is primarily used for terminal sterilization.

Abbreviations and Acronyms

AAHC Accreditation Association for Ambulatory Health Care
AAMI Association for the Advancement of Medical Instrumentation
AFMS Air Force Medical Service
AIDS Acquired Immunodeficiency Syndrome
AORN Association of periOperative Registered Nurses
AST Association of Surgical Technologists
CDC Centers for Disease Control and Prevention
ENT ear, nose, and throat
EPA Environmental Protection Agency
FIFO first in, first out
HIV Human Immunodeficiency Virus
HSI Health Services Inspection
ICC Infection Control Committee
ICP Infection Control Program
IV intravenous
MTF military treatment facility
NCOIC noncommissioned officer in charge
OI operating instructions
OR operating room
OSHA Occupational Safety and Health Administration
PPE personal protective equipment
PPM parts per million
PSI pounds per square inch
SPD Sterile Processing and Distribution
TB tuberculosis
TJC The Joint Commission or Joint Commission

Student Notes

Student Notes

AFSC 4N151
A4N151 02 1506
Edit Code 03