MICROORGANISMS
and Their Role in Central Service

LEARNING OBJECTIVES

1. Describe different types of infection causing bacteria
2. Describe biofilms and antibiotic-resistant viruses, and their impact on Central Service
3. Explain how following best practices keeps Central Service professionals and patients protected from infectious agents

F OR EVERY CERTIFIED REGISTERED CENTRAL SERVICE TECHNICIAN (CRCST), the basic educational foundation regarding microbiology should already have been laid. This self-study course will expand upon the basics and address some of the microbes that are of particular concern when performing medical device processing. The CS technician’s role in healthcare is to prevent infections, and the old adage “prevention is the best medicine” is still relevant today. Understanding the science of microbiology and how CS practices can prevent infections is key to infection prevention. This is more important than ever due to antibiotic-resistant bacteria and viruses.

OBJECTIVE 1: DESCRIBE DIFFERENT TYPES OF INFECTION-CAUSING BACTERIA

Antibiotics are used to treat bacterial infections. In the past, patients with bacterial infections were prescribed antibiotics and, in most cases, those infections were successfully treated. Over the years, however, some bacteria have developed a resistance to the antibiotics that would typically be used to kill the microorganism. As a result, bacterial infections have again become a threat, and cleaning, disinfection and sterilization of medical devices are increasingly important because many of these infections cannot be easily treated. Some of the antibiotic-resistant bacteria commonly diagnosed in healthcare facilities include:

- **Vancomycin-resistant enterococci (VRE)** – VRE is the resistance of enterococci to the antibiotic used to treat it, vancomycin. Enterococci bacteria live in the intestines and on skin, usually without causing problems; however, enterococci can cause a serious infection, especially in those who are weak or ill. Enterococci cause a range of illnesses – including bloodstream infections, surgical site infections and urinary tract infections –
and these infections are most commonly seen in the patient population. More than 66,000 infections from enterococci occur each year, 20,000 of which are drug resistant. Roughly 1,300 deaths occur each year due to these infections.

**Methicillin-resistant Staphylococcus aureus (MRSA)** – One of the most common healthcare-associated infections, MRSA refers to the resistance of Staphylococcus aureus to the antibiotic used to treat it, methicillin. It is spread through direct skin-to-skin contact, touching contaminated surfaces such as patient care equipment, and even through the air. MRSA can survive for weeks on contaminated surfaces, so it is vital to thoroughly and properly clean and disinfect patient care equipment. It is not uncommon for people to have MRSA on their skin and not be aware. A person may never get an infection and be unaware they are spreading this microbe. These people are called “carriers.” MRSA can cause skin and wound infections that can lead to sepsis and death. There are over 80,400 severe MRSA infections each year and over associated 11,000 deaths.

**Carbapenem-resistant Enterobacteriaceae (CRE)** – The term used for bacteria that have developed resistance to many antibiotics, including carbapenem. This type of superbug is on the rise among healthcare patients. CRE lives in the intestines of some people and is not a problem until it moves outside the intestines. Once that occurs, it can result in deadly infections in the bloodstream, lungs and urinary tract; this can lead to the development of pneumonia and meningitis. CRE can survive on inanimate surfaces for a long period of time. It is transmitted through contaminated inanimate surfaces, including medical equipment. CRE outbreaks have been linked to contaminated flexible endoscopes, including the duodenoscope.

Over 9,000 CRE infections and 600 deaths occur each year.

**Pseudomonas**

*Pseudomonas aeruginosa* is a common type of infection-causing bacteria. Serious infections from *Pseudomonas aeruginosa* usually occur in people in healthcare facilities and with weakened immune systems. Pneumonia, infections of the blood and post-surgical infections can lead to serious illness and death for those infected. *Pseudomonas* infections in healthy people can occur, but are usually able to be successfully treated.

*Pseudomonas* is found mostly in the environment, especially in moist areas. It can be spread by equipment or healthcare workers’ hands, which is one of the many reasons hand hygiene is so important.

Infections from *Pseudomonas aeruginosa* have been shown to be passed from improperly-cleaned medical devices that have undergone a sterilization process. In one such case, the infection was spread through the use of an arthroscopic shaver that was found to have debris in the lumen. Even though the shaver had undergone repeated decontamination and sterilization cycles, the debris was not removed, which allowed the bacteria to survive. Seven patients who all used the same arthroscopic shaver acquired a surgical site infection as a result.

**Endotoxins**

Endotoxins are located inside the cell wall of gram-negative bacteria. Endotoxins exert their effects when gram-negative bacteria die and their walls undergo lysis (breaks open), thus liberating the endotoxin.

Endotoxins can cause chills, fever and weakness, generalized aching and, in some cases, shock and death. Endotoxins can result in Toxic Anterior Segment Syndrome (TASS), an acute post-operative inflammatory reaction in which a noninfectious substance enters the anterior segment of the eye and induces toxic damage to the intraocular tissues. Endotoxins can also induce miscarriage and prevent blood from clotting.

Tap water has endotoxins at low levels that are safe for drinking. Endotoxins are a concern in CS because they are heat-stable; thus, they can resist steam sterilization and will remain biologically active. The prevention of endotoxins begins with water quality. Untreated water can contain endotoxins, which can be deposited onto instruments during the final rinse; hence, it is important to have water quality checks performed and to use pure (critical) water as a final rinse. Thorough cleaning is essential to remove or destroy microorganisms and eliminate endotoxins. Cleaning equipment verification tests should be used at least daily on washer-disinfectors to monitor cleaning efficacy.

**OBJECTIVE 2: DESCRIBE BIOFILMS AND ANTIBIOTIC-RESISTANT VIRUSES AND THEIR IMPACT ON CS**

**Biofilm**

During the cleaning process, it is important to thoroughly remove all debris as soon as possible to prevent the formation of biofilm. Biofilm is a collection of microorganisms that attaches to surfaces and each other and forms a colony. The colony produces a protective gel that is very difficult to penetrate with detergents and disinfectants. Once attached, it is difficult to remove. When biofilm originally forms, it is not visible to the naked eye; however, once it grows, it may be visible. Dental plaque is an example of a biofilm. Dental plaque forms from not thoroughly brushing teeth. Over time, the plaque grows and becomes visible.

On instrumentation, biofilm can begin to form within minutes, which is why point-of-use treatment is required and instrumentation should be cleaned as soon as possible. While the instruments

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On instrumentation, biofilm can begin to form within minutes, which is why point-of-use treatment is required and instrumentation should be cleaned as soon as possible. While the instruments
are sitting, awaiting processing, the biofilm microorganisms are sending out messages to attract other microorganisms to join the biofilm-forming community. As this occurs, they tightly grip the surface, making it even more difficult to remove.

Once the biofilm is attached, the colony begins to ooze a gooey substance, called a matrix, to cover itself. This substance traps any organic debris, including blood, tissue, fat and mucous left nearby, which serves as a food supply and adds strength to the matrix; this allows biofilm to continue increasing in size and number of microorganisms. The longer it takes for an instrument to be reprocessed, the more difficult it becomes to completely remove thickened, strongly-attached biofilm structures. If biofilm is not removed during cleaning, the disinfectant may not be able to kill or deactivate the microorganisms. Research studies have shown that bacteria inside a fully-developed biofilm can be 10 to 1,500 times more resistant to disinfectants than the same bacteria outside of the biofilm.

Flexible endoscopes with internal channels are the perfect environment for biofilm to thrive. The channels are exposed to debris and fluids during use, resulting in a moist, dark environment that is difficult to clean and visually inspect. Flexible endoscope manufacturers provide specific instructions for point-of-use treatment to prevent biofilm formation. This treatment involves wiping down and flushing the endoscope immediately after use, then keeping the device moist (e.g., with an enzymatic product). Ideally, endoscopes should be cleaned within one hour of use to prevent debris from drying and biofilm from forming on instruments; however, for all instruments, it is important that thorough cleaning takes place as soon as possible to prevent biofilm formation. If debris is missed during the cleaning process, biofilm can be baked on during the disinfection/sterilization process. This will make biofilm harder to remove and will render the disinfection/sterilization process ineffective.

Viruses
Viruses can be deadly and are contagious. They are much smaller than bacteria – typically only 20 to 400 nanometers (one billionth of a meter) in diameter. Unlike bacteria, viruses cannot thrive outside the body because they rely on a host for energy production, reproduction and survival. They also differ in structure and function, with the ability to only reproduce inside the living cells of other organisms. Viruses can infect all types of life forms, from animals and plants to other microorganisms, including bacteria. Viruses are the cause of many human diseases, from the common cold and influenza to chickenpox and more. Some of the most notable recent outbreaks of viral infections were the 2014 outbreak of Ebola and the 2009 1N1/swine flu. Certain types of cancers have been linked to viruses; however, most viruses do not cause cancer.

The life cycle of viruses has several phases. The virus first attaches to the host via specific proteins on the cell surface. These proteins are generally receptors that differ depending upon the type of virus targeting the cell. Once attached, the virus then enters the cell by endocytosis or fusion. The host's mechanisms are used to replicate the Deoxyribonucleic Acid (DNA) or Ribonucleic Acid (RNA), the blueprint of the virus, as well as provide the essential proteins. After these new viruses mature, the host is disintegrated and the new viruses are released into circulation; then, the cycle repeats.

Some viruses can remain in a host for a long period of time without causing any changes. This is known as the dormant phase. Once activated, these viruses can immediately begin the life cycle phase. An example of a virus in a dormant phase is Human Immunodeficiency Virus (HIV) which can lead to Acquired Immunodeficiency Syndrome (AIDS), if not treated. Unlike some other viruses, the human body can't rid itself of HIV completely, even with treatment. HIV can remain dormant for 10 years.

Antibiotics are ineffective against viruses; anti-viral medications may be needed for their treatment. Viruses that resist the effects of these medications are often called drug-resistant viruses.

OBJECTIVE 3: EXPLAIN HOW FOLLOWING BEST PRACTICES KEEPS CENTRAL SERVICE PROFESSIONALS AND PATIENTS PROTECTED FROM INFECTIOUS AGENTS

This lesson plan has identified some of the different types of microorganisms that affect daily practice in the CS department. To mitigate risks, CS technicians need to follow best practices to protect themselves when working in in the department.

Employees in the decontamination room must properly don (put on) the required personal protective equipment (PPE) to protect themselves from microorganisms. When leaving the decontamination room, it is important that employees properly doff (remove) the PPE to prevent carrying microorganisms to other areas. Proper handwashing is a primary method of decreasing healthcare-associated infections and should be performed diligently and frequently to protect both the CS technician and the patient. To reduce the spread of microorganism from hands, handwashing should always be performed after removing gloves, and also while preparing instrumentation and handling sterile packages. Fingernails should not be more than ¼-inch long since the subungual area of the fingernail has the largest number of microorganisms on the hand. Rings should not be worn because research has shown rings may result in colonization of the hands with bacteria. Long fingernails and rings may also tear gloves.
Properly transporting soiled devices protects personnel and patients. Not only is this best practice, but properly transporting instrumentation in closed, puncture-resistant containers with the Biohazard insignia is an Occupational Safety and Health Administration (OSHA) regulation that must be followed. This practice keeps biohazardous contents contained, thus preventing cross-contamination and employee exposure.

Following medical device manufacturers’ instructions for use (IFU) is vital to ensure the appropriate processes are consistently followed. All items must be thoroughly cleaned so disinfection or sterilization can be accomplished. During the disinfection or sterilization process, all surfaces must have contact with the sterilant or disinfectant, for the prescribed amount of time; therefore, instruments should be disassembled and opened, if possible. Following IFU for detergents is also essential. Failing to use the recommended amount of detergent for the water level, for example, results in the cleaning solution being too diluted, which renders it ineffective. Using too much detergent may leave a residue and be difficult to rinse thoroughly. Sterilants and high-level disinfectants must also be used exactly according to their IFU because their validation testing demonstrated that is the most effective way to use them.

Thoroughly cleaning lumens and using pure water as a final rinse can prevent endotoxins from forming. Using a proper brush that is clean and of the proper size, and then checking the lumens for cleanliness using a clearing verification test or borescope, can prevent debris from remaining in a lumened device.

The preparation and packaging area of the CS department should also be kept clean. If an instrument appears soiled, it should not be cleaned in this area; instead, it should be returned to the decontamination area where the staff wear PPE and have the correct cleaning equipment to clean the item. Doing so will contain the debris to the decontamination area and protect preparation and packaging professionals from exposure to potential contaminants.

Personnel entering CS on the clean side should wear freshly-laundered surgical attire that is provided by and donned at the healthcare facility. This attire should then be removed when leaving the facility. Wearing clean attire from a controlled laundering system minimizes the introduction of microorganisms and lint from personnel to items being processed and to the environment. Removing this attire and changing into personal clothing reduces the risk of transferring pathogenic microorganisms from the healthcare facility to home and family.

CONCLUSION
Microbiology is a highly-complex science that has a major impact on patient care. Bacteria are becoming resistant to antibiotics used to treat infections, and viruses are becoming drug-resistant, as well; therefore, the role of the CS technician is more important than ever to prevent infections. Employees’ dedication to ensuring all medical devices are thoroughly cleaned, disinfected or sterilized, the CS environment is kept clean, and proper hand hygiene and other infection prevention strategies are followed will go a long way toward preventing healthcare-associated infections.

RESOURCES

WANT TO BE AN AUTHOR?
IAHCSMM is seeking volunteers to write or contribute information for our CRCST Self-Study Lessons. Doing so is a great way to contribute to your own professional development, to your Association, and to your Central Service department peers. IAHCSMM will provide guidelines and help you with the lesson to ensure it will be an enjoyable process. For more information, please contact Natalie Lind (natalie@iahcsmm.org).
1. Which of the following medications are prescribed to treat bacterial infections?
   a. Analgesics
   b. Antibiotics
   c. Measles, mumps and rubella vaccine
   d. Statins

2. Over the years, some bacteria have become more difficult to kill due to:
   a. The cost of medication
   b. Bacteria becoming resistant to antibiotics
   c. Bacteria becoming resistant to multi-drug-resistant viruses
   d. US Food and Drug Administration regulations

3. A person who unknowingly has Methicillin-resistant Staphylococcus aureus on their skin and may never acquire an infection is referred to as an:
   a. Carrier
   b. Spreader
   c. Infectious agent
   d. Pathogen

4. Which antibiotic-resistant bacteria have been found in duodenoscopes?
   a. Vancomycin-resistant Enterococci
   b. Methicillin-resistant Staphylococcus aureus
   c. Carbapenem-resistant Enterobacteriaceae
   d. Statin-resistant plaque

5. Endotoxins exert their effects when gram-negative bacteria die and their walls undergo ______ to liberate the endotoxin.
   a. Cavitation
   b. Osmosis
   c. Lysis
   d. Resistance

6. Endotoxins can cause:
   a. Hair loss and infection
   b. Miscarriage and prevent blood from clotting
   c. Infection and blisters
   d. Weight loss and blisters

7. Endotoxins can be found in:
   a. Insects
   b. Plants
   c. Dust
   d. Water

8. A collection of microorganisms that attach to surfaces and each other, and form a colony that produces a protective gel that is very difficult to penetrate with detergents and disinfectants is called:
   a. Biofilm
   b. Antibiotic-resistant bacteria
   c. Virus
   d. Pseudomonas

9. Biofilm can begin forming:
   a. After sterilization
   b. With the right chemicals
   c. With a hole in a wrapper
   d. Within minutes

10. Pseudomonas is found mostly in:
    a. Water
    b. The environment
    c. Endoscopes
    d. Basin sets

11. Viruses can only reproduce:
    a. In high humidity
    b. In low temperatures
    c. Inside living cells
    d. Inside lumened devices

12. Viruses can infect all types of life forms, from animals and plants to microorganisms, including bacteria.
    a. True
    b. False

13. A virus can cause:
    a. Biofilm
    b. Ebola
    c. Staphylococcal infections
    d. Vancomycin-resistant Enterococci

14. Antibiotics are used to treat viruses.
    a. True
    b. False

15. To prevent infections it is vital that medical devices are:
    a. Thoroughly cleaned, disinfected or sterilized
    b. Economical
    c. Porous
    d. Kept in an orderly fashion to reduce location time and inventory costs

16. When working in the decontamination area, employees must wear which of the following to protect themselves from microorganisms?
    a. A respirator
    b. Personal protective equipment
    c. Utility gloves
    d. An isolation gown

17. Which part of the finger contains the largest number of microorganisms?
    a. The palm
    b. The wrist
    c. The subungual area of the fingernail
    d. The back by the dorsal venous network

18. A final pure water rinse for lumens is recommended to:
    a. Decrease drying time
    b. Increase drying time
    c. Prevent viruses from multiplying
    d. Prevent endotoxins from forming

19. If an instrument is not cleaned:
    a. The sterilization time will need to be extended
    b. The debris can be brushed off in packaging
    c. The instrument cannot be sterilized
    d. The hydrogen peroxide sterilizer will abort

20. The dress code or attire for the preparation and packaging area is:
    a. Clean clothes
    b. Clean scrub attire that is provided by the facility
    c. Scrub attire that can be laundered at the healthcare facility and donned at the facility
    d. A clean uniform with a clean lab coat