





Healthcare-Associated Biofilm: Bacterial Contamination, Complications and Prevention

BY ROBERT GLOVER, MSMS, BS, AS, CRCST, CIS

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LEARNING OBJECTIVES

1. Learn how biofilm forms and proliferates
2. Identify the risks associated with biofilm formation on medical devices
3. Discuss methods to prevent or remove biofilm on medical devices

Modern healthcare relies on the delivery of clean, high-level disinfected or sterile medical devices to reduce the risk of infections and ensure safe, high-quality patient care. The Sterile Processing department (SPD) plays a pivotal role in quality outcomes and contributes to the success of many departments in healthcare facilities. Departments rely on Sterile Processing (SP) professionals to process instruments promptly; however, numerous challenges SP technicians encounter each day can result in service delays or process failures. Biofilm formation on devices and equipment is one such challenge that can affect technicians' ability to clean and sterilize instruments effectively, increasing the risk of healthcare-associated infections (HAIs) and other serious outcomes.

Objective 1: Learn how biofilm forms and proliferates

Bacteria that produce biofilm are capable of being 1,000 times more

resistant to antibiotics and cleaning methods than non-biofilm-producing bacteria. According to the Centers for Disease Control and Prevention (CDC), at least one HAI will occur in every 31 patients, which translates into millions of infections worldwide.¹ It is also reported that gram-positive and gram-negative bacteria cause 70% of HAIs in intensive care units (ICUs). Biofilm production is a primary virulence mechanism and distinguishing feature of bacterial pathogens.³ To reduce such infections, healthcare providers must prioritize biofilm prevention and reduction of bacterial contamination on medical devices.

Biofilm is a colony of bacteria that adheres to surfaces and forms a slimy, protective matrix that makes removal difficult. Biofilm formation begins with adhesion. Cell structures involved in this process are adhesins, pili and fimbriae, which are located on the cell's outer surface structures. These structures allow attachment to non-cellular surfaces, such as medical



devices. The role of the matrix is to protect against antimicrobial agents and antibiotics, thereby enabling the growth of highly resistant microorganisms.

Bacterial growth depends on environmental conditions that support nutrient availability, which feeds the bacteria. Bacterial cell-to-cell communication, known as quorum sensing, enables bacteria to detect population density and adjust replication rates in response to nutrient availability. If the population density is too high, the bacteria will stop growing. If the population density is low and environmental conditions are favorable for growth, the bacteria will multiply and seek to expand. Bacteria can even use flagella, whiplike structures that aid motility and help them colonize more of the surface.

The longer bacteria remain on a surface, the greater the risk of biofilm formation.

Objective 2: Identify the risks associated with biofilm formation on medical devices

The Association for the Advancement of Medical Instrumentation (AAMI) standards emphasize that biofilm on surgical instruments is a significant infection risk and must be prevented and removed. Numerous medical conditions are associated with biofilm-contaminated devices and equipment. Urinary catheters, for example, are susceptible to uropathogens or pathogens that infect the urinary tract. This is especially true when urinary catheters are used long-term. Common uropathogens include *Escherichia coli*, *Klebsiella pneumoniae*, and *Proteus mirabilis*. These uropathogens are known to form biofilms on catheter surfaces, which can

cause urinary tract infections (UTIs).

It is important to note that catheter placement at a specific site determines colonization by bacterial species. This is true with central venous catheters, which are placed in the neck or chest. Central venous catheters are commonly colonized by *Staphylococcus aureus* and *Staphylococcus epidermidis*. Biofilm on the surface of the central venous catheters can lead to serious complications such as sepsis. Another common site for biofilm is endotracheal tubes used in mechanical ventilation. Biofilm formation in endotracheal tubes is usually caused by *Pseudomonas aeruginosa* and *Acinetobacter baumannii*. It can cause pneumonia, more commonly in intensive care units (ICU), where patients are immobilized and need assistance to breathe.

Orthopedic implants that acquire biofilm from *Staphylococcus aureus* and *Staphylococcus epidermidis* can lead to chronic infections in patients. When this occurs, a surgical revision and antibiotic therapy are often needed to treat the infection. Biofilm on prosthetic heart valves and pacemakers associated with *Streptococcus* and *Staphylococcus* can lead to a life-threatening condition called infective endocarditis, an inflammation of the heart's inner membrane.

Objective 3: Discuss methods to prevent and remove biofilm on medical devices

Understanding the factors in the healthcare environment that contribute to bacterial growth helps determine how to prevent and remove biofilm from medical devices effectively. Instruments soiled with blood, saliva, urine or mucus offer suitable environmental conditions for biofilm formation and proliferation.

Diligent point-of-use (POU) treatment, proper handling, strict adherence to the manufacturer's instructions for use (IFU), and ensuring instruments are visibly clean and free of soil before HLD or sterilization begins are critical steps for preventing biofilm from forming and multiplying.

Biofilm can harbor heat-stable endotoxins that survive sterilization, leading to infections.⁴ Therefore, it is much easier to clean instruments/equipment before biofilm forms. POU treatment is the first critical step in prevention. It involves wiping gross soil with a sterile, water-moistened sponge (never use saline, which can cause corrosion), flushing lumens with sterile water, and keeping instruments moist with enzymatic spray or gel (or covering instruments with a water-moistened towel) until decontamination can begin. Also critical is ensuring that used devices are transported to the SPD as soon as possible after the procedure so decontamination can begin promptly. The goal is to prevent organic matter from drying on and in device surfaces, which makes its removal more challenging. Bacteria within biofilm can be up to 3,000 times more resistant to disinfectants than free-floating bacteria.

Following the device manufacturers' IFU is always essential to ensure correct disassembly, cleaning and reprocessing. Box locks should be in an open position, and devices should be properly disassembled (if appropriate) to expose all surfaces to detergents and water. Closed ratchets and improperly disassembled devices can trap soil and bacteria. Visual inspection, ideally with a lighted magnifier or borescope, is a vital step that must occur after cleaning and before disinfection or sterilization to verify that devices



are free of bioburden. Strict IFU adherence for chemistries and processing equipment is also critical, as is ensuring proper water quality. Biofilm thrives in water systems with low flow rates, stagnant water, “dead legs” in piping, and on rough internal surfaces. Further, biofilm-contaminated water can cause instrument staining, pitting and corrosion, and spread opportunistic pathogens such as *Pseudomonas aeruginosa*, *Legionella*, and non-tuberculous Mycobacteria.

Conclusion

Biofilm prevention and removal are crucial, and many efforts and dollars have been invested in researching ways to reduce its presence. Using single-use instrumentation or devices with antimicrobial coatings to prevent biofilm formation and reduce the risk of HAIs are two such approaches; however, many devices are not available with those options, and even if they were, their widespread adoption would be unrealistic for most facilities. Given the abundance of reusable devices in facilities’ inventories, SP professionals and their team members in procedural areas must receive training to understand the science of biofilm formation and implement proven strategies to prevent it, such as performing point-of-use treatment to remove gross bioburden and keep instruments moist and ensuring thorough decontamination begins as soon as possible following the procedure. Such efforts will support infection prevention and successful procedural outcomes for the patient, while also extending instrument life and limiting the organization’s liability. 

RESOURCES

- Centers for Disease Control and Prevention. HAIs: Reports and Data. <https://www.cdc.gov/healthcare-associated-infections/php/data/index.html>
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- Association for the Advancement of Medical Instrumentation. ANSI/AAMI ST79:2017(R)2022 *Comprehensive guide to steam sterilization and sterility assurance in health care facilities*.

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CIS Self-Study Lesson Plan Quiz:

Healthcare-Associated Biofilm: Bacterial Contamination, Complications and Prevention

Lesson No. CIS 315 (Instrument Continuing Education – ICE) · Lesson expires April 2029

1. Which structure allows biofilm to protect itself?
 - a. Fimbriae
 - b. Spore field
 - c. Cohesive shell
 - d. None of the above
2. Biofilm is a significant contributor to:
 - a. Healthcare-associated infections
 - b. Washer-disinfectant damage
 - c. Work surface contamination
 - d. Employee hand contamination
3. When bioburden is not removed:
 - a. Sterilization processes may fail
 - b. Disinfection processes may fail
 - c. Patient safety is compromised
 - d. All the above
4. The process to prevent biofilm:
 - a. Must be initiated by the clinician before starting the procedure
 - b. Begins after decontamination and before high-level disinfection or sterilization
 - c. Should begin immediately after the procedure
 - d. Begins with a mechanical washer bioburden cycle
5. Biofilm formation begins with:
 - a. Cellular degradation
 - b. Cohesion
 - c. Adhesion
 - d. Passivation
6. Antimicrobial coating that is available for some medical devices:
 - a. Contributes to biofilm formation
 - b. Is the only reliable way to prevent biofilm formation
 - c. Can be applied in the decontamination area
 - d. Can help prevent biofilm formation
7. Biofilm on prosthetic heart valves and pacemakers is associated with:
 - a. Bloodstream infections
 - b. Valve replacement surgery
 - c. Inflammation of the heart
 - d. All the above
8. Bacteria that produce biofilm are capable of being 1,000 times more resistant to cleaning methods than those that do not produce biofilm.
 - a. True
 - b. False
9. Biofilm removal is a difficult task due to the adhesion of the biofilm and:
 - a. The lack of stiff-bristled brushes to remove it
 - b. The protective properties of the slimy matrix
 - c. The lack of time available for processing
 - d. The need to adhere to more stringent water quality standards
10. One way to reduce the risk of biofilm contamination is to:
 - a. Sterilize used instruments before cleaning them
 - b. Perform decontamination in the procedure room
 - c. Soak devices in saline until decontamination can begin
 - d. Utilize single-use instrumentation
11. Bacterial growth depends on:
 - a. Environmental conditions
 - b. The size of the bacteria
 - c. The amount of light present
 - d. All the above
12. Quorum sensing refers to cell-to-cell communication that:
 - a. Quickly eradicates bacteria
 - b. Causes cells to degrade
 - c. Enables bacteria to detect population density and adjust replication rates in response to nutrient availability
 - d. Prevents biofilm formation
13. Instruments soiled with blood, saliva, urine or mucus:
 - a. Always contribute to biofilm formation
 - b. Can only be cleaned if the instrument is a solid piece
 - c. Create a suitable environment for biofilm formation
 - d. Must be cleaned within 15 minutes after use
14. A flagella is:
 - a. A dense, sticky layer that traps microorganisms
 - b. A whiplike structure that aids in motility to help the bacteria colonize more of the surface
 - c. A crusty coating on biofilm that makes it difficult for chemicals to penetrate
 - d. A type of microorganism most associated with HAIs
15. Understanding more about bacterial growth allows for a better understanding of how to prevent and remove biofilm from medical devices.
 - a. True
 - b. False

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