*Short communication*

Microbial Contaminants on Medical Devices: A Review

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ABSTRACT

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| Microbial contamination of medical devices is a critical issue in healthcare, as it can lead to serious infections and complications in patients. Medical devices, ranging from simple tools like syringes to complex apparatuses such as ventilators, are integral to modern medical care. The common materials used in medical devices are polyethylene, polycarbonate, aluminum, silicone, and plastics. However, their potential to harbor and transmit microorganisms can lead to severe infections and complications if not properly managed. Contamination can occur due to improper handling, insufficient sterilization, and the presence of biofilms on device surfaces. The study aims to review the common microbial contaminants on medical devices. The review suggests that the most frequent contaminants found on medical devices include *Staphylococcus aureus*, *Escherichia coli, Enterococcus species, Pseudomonas aeruginosa* and Candida species. Moreover, biofilms can grow on the surfaces of medical devices by a variety of bacteria and fungi. Furthermore, infection risk increases with the length of time a device is utilized. To mitigate these risks, effective reprocessing/cleaning of medical devices is essential. Considering this, the review suggests the many forms of microbial contamination and their connection to medical devices. The study emphasizes the need to follow strict reprocessing, and cleaning protocols to prevent infections and maintain patient safety. Lastly, medical device manufacturers and healthcare providers need to maintain awareness to make sure that the devices are safe, sterile, and effective. |

*Keywords: Contamination; Medical Devices; Biofilms; Virus; Fungi; Bacteria*

1. INTRODUCTION

Microbial contamination of medical devices is a significant concern in healthcare, as it poses a direct threat to patient safety. Microbial contamination of medical devices is a critical issue in healthcare that poses substantial risks to patient safety. Medical devices, ranging from simple tools like syringes to complex apparatuses such as ventilators, are integral to modern medical care. However, their potential to harbor and transmit microorganisms can lead to severe infections and complications if not properly managed.

Multidrug-resistant (MDR) microorganisms are a concern to human health in several areas, including medical devices. Microbial adaptation to unfavorable environmental circumstances has rapidly changed since the 1970s when legal classifications for sterilizing and disinfecting medical devices were developed (Jonathan et al., 2021).

Microbial contamination often results from inadequate cleaning and sterilization processes. Biofilm formation on medical devices further complicates the issue, as biofilms are highly resistant to conventional cleaning methods and can harbor a diverse community of pathogens (Pajkos et al., 2004) (Desrousseaux et al., 2013). The persistence of nosocomial pathogens on inanimate surfaces, including medical devices, underscores the importance of rigorous disinfection protocols to prevent infections (Kramer et al., 2006; Ahmed et al., 2024). Nevertheless, research suggests that Triton X-100 and Tween 80 (Polysorbate 80) are the two popular non-ionic, synthetically derived, and regularly used surfactants in laboratories. Furthermore, rhamnolipids from *P. aeruginosa* W10 were also known to disperse biofilms of various industrial bacterial strains on the pipelines. Since biosurfactants are usually associated together with isomers and cogeners and rarely in pure form, the purification process could be exhaustive and expensive (Shrestha et al., 2022). Moreover, halogenated furanone compounds extracted from red seaweed *Delisea pulchra* can inhibit colonization, swarming and biofilm formation of Gram-negative bacteria, attenuate bacterial virulence and prevent bacterial infections (Zhang et al., 2022).

The classification of medical devices based on their risk of infection and the necessary level of disinfection has been extensively discussed in foundational literature (Spaulding, 1968). Furthermore, contemporary reviews emphasize the challenges associated with medical device cleaning and sterilization, offering insights into both existing problems and potential solutions (Furness, 2016). Biofilm-associated infections, which are common in healthcare settings, highlight the need for effective control measures to mitigate the risks posed by microbial contamination (Percival et al., 2015). Ensuring the safety and efficacy of medical devices requires adherence to strict reprocessing protocols and ongoing research to improve infection control practices. Research suggests that the most common control measures are the prevention of bacterial adherence and killing microbes through surface-associated mechanisms or coatings that emit antibacterial chemicals. To combat the growing resistance to conventional antibiotics, metal and metal oxide nanoparticles, as well as 2D nanomaterials, have provided innovative substitutes for antibiotic treatments of hospital-acquired illnesses linked to biofilms (Mishra et al., 2024; Li et al., 2023). Moreover, in vitro efficacy studies of phages, lysins, and AMPS as standalone or combination products demonstrate promising results (Garvey, 2023). Table 1 (Klein., 2015; Pfaller & Diekema., 2010; Hooton & Gupta., 2016; Peleg & Hooper., 2010; Podschun & Ullmann., 1998; Rice., 2008; Glickman & McAdam., 2007; Murray., 1998).

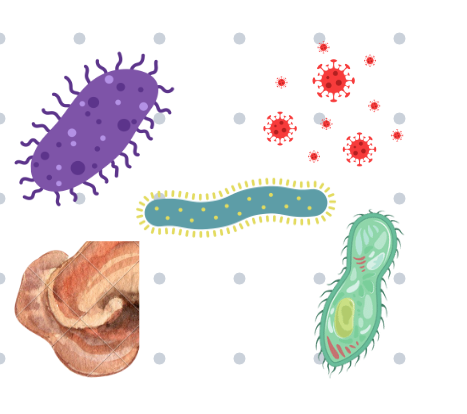
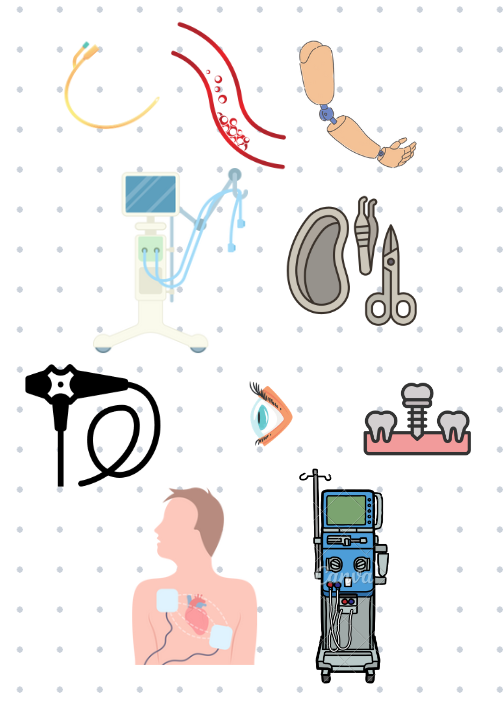
Table 1: Medical device contaminants

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| --- | --- | --- | --- |
| Bacteria | Viruses | Fungi | Other Pathogens |
| Staphylococcus aureus | Hepatitis B and C viruses | Candida species | Protozoa |
| Escherichia coli | Human Immunodeficiency Virus | Aspergillus species | Helminths |
| Pseudomonas aeruginosa | Influenza virus | Cryptococcus neoformans |  |
| Klebsiella pneumonia | Herpes simplex virus |  |  |
| Enterococcus species | Human Papillomavirus |  |  |
| Acinetobacter baumannii | Norovirus |  |  |
| Clostridioides difficile | Respiratory Syncytial Virus |  |  |

2. Medical devices and their Microbial infections

Device-associated infections (DAIs), or microbial infections connected to medical devices, are a serious problem in hospital environments Figure 1.

**Figure 1: Common Microbial contamination on medical devices**



**Microbes**

**Medical Devices**

**Contaminating**

Serious consequences are extended hospital stays, more healthcare expenses, and, in extreme circumstances, death can result from these infections (Table 2).

**Table 2: Common types of device-associated infections and microbes**

|  |  |  |
| --- | --- | --- |
| **Type of Device** | **Microbes** | **References** |
| Catheter-Associated Urinary Tract Infections (CAUTIs) | Escherichia coli  Klebsiella species  Proteus mirabilis  Pseudomonas aeruginosa  Enterococcus species | Raad et al., (2007) |
| Central Line-Associated Bloodstream Infections (CLABSIs) | Staphylococcus aureus (including MRSA)  Coagulase-negative staphylococci (e.g., Staphylococcus epidermidis)  Enterococcus species  Gram-negative bacteria (e.g., Klebsiella, Pseudomonas aeruginosa)  Candida species |
| Ventilator-Associated Pneumonia (VAP) | Staphylococcus aureus (including MRSA)  Pseudomonas aeruginosa  Klebsiella pneumoniae  Escherichia coli  Acinetobacter species | Chastre, & Fagon,(2002). |
| Surgical Site Infections (SSIs) | Staphylococcus aureus (including MRSA)  Coagulase-negative staphylococci  Enterococcus species  Escherichia coli  Pseudomonas aeruginosa | Mangram et al., 1999 |
| Prosthetic Joint Infections | Staphylococcus aureus (including MRSA)  Coagulase-negative staphylococci  Enterococcus species  Propionibacterium acnes | Tande & Patel, 2014. |
| Cardiac Device-Associated Infections | Staphylococcus aureus (including MRSA)  Coagulase-negative staphylococci  Enterococcus species  Gram-negative bacteria | Sohail et al., 2007 |
| Catheters (Urinary catheters, central venous catheters, peripheral intravenous catheters) | Bacteria: Escherichia coli, Staphylococcus aureus (including MRSA), Pseudomonas aeruginosa, Enterococcus species  Fungi: Candida species | Makki et al., 1981; Grady et al., 2011 |
| Endoscopes (Gastrointestinal endoscopes, bronchoscopes, laparoscopes) | Bacteria: Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Helicobacter pylori  Viruses: Hepatitis B and C viruses  Fungi: Candida species | Rutala et al., 1999 |
| Ventilators and Respiratory Equipment (Mechanical ventilators, nebulizers, CPAP machines) | Bacteria: Pseudomonas aeruginosa, Acinetobacter baumannii, Staphylococcus aureus (including MRSA)  Viruses: Influenza virus, Respiratory Syncytial Virus (RSV)  Fungi: Aspergillus species | McLean et al., 2016; Denning et al., 2006 |
| Surgical Instruments (Scalpels, forceps, scissors, retractors) | Bacteria: Staphylococcus aureus (including MRSA), coagulase-negative staphylococci, Escherichia coli  Viruses: Hepatitis B and C viruses, HIV  Fungi: Candida species | Mangram et al., 1999 |
| Implantable Devices (Pacemakers, prosthetic joints, cardiac stents, artificial valves) | Bacteria: Staphylococcus aureus (including MRSA), coagulase-negative staphylococci, Propionibacterium acnes  Fungi: Candida species | Baddour et al., 2015; Rickard et al., 2018 |
| Dialysis Machines (Hemodialysis machines, peritoneal dialysis equipment) | Bacteria: Pseudomonas aeruginosa, Klebsiella pneumoniae, Escherichia coli  Fungi: Candida species | Kallen et al., 2007; Holmes et al., 2005 |
| Contact Lenses and Ophthalmic Devices (Contact lenses, intraocular lenses, ophthalmic surgical instruments) | Bacteria: Pseudomonas aeruginosa, Staphylococcus aureus, Serratia marcescens  Fungi: Fusarium species  Protozoa: Acanthamoeba species | Dart et al., 2008; Willcox et al., 2007 |

**2.1 Microbial Infections on devices**

1. Biofilms can grow on the surfaces of medical devices by a variety of bacteria and fungi. Comprising intricate groups of bacteria, biofilms are shielded from antibiotics and the host's immune system by an extracellular matrix (Donlan and Rodney., 2001).
2. Microbes can enter the body through devices that are not properly sterilized or by insertion procedures that do not use aseptic methods.
3. The risk of infection increases with the length of time a device is utilized. This is particularly valid for indwelling medical equipment like central lines and catheters.
4. Patients having invasive procedures, those with compromised immune systems, and preexisting medical disorders are more susceptible to device-associated infections (Hooton et al., 2009).

**2.2 Prevention**

Ensuring proper hand hygiene, sterile procedures, and aseptic techniques during device insertion and maintenance; Regularly checking and maintaining devices to identify early signs of infection; Removing devices as soon as they are no longer needed to reduce the risk of infection; Utilizing devices coated or impregnated with antimicrobial agents to prevent microbial colonization and biofilm formation; Educating patients and healthcare workers about the importance of device care and early signs of infection.

4. Conclusion

Strict quality control procedures, regulatory requirements, and sterilization techniques are necessary to avoid contamination during the production, storage, and use of medical devices. Since it may result in microbial infections, device function failure, and adverse health consequences, microbial contamination on medical devices poses a serious risk to patient safety. Advances in materials and sterilizing technology, in conjunction with regular surveillance, considerably mitigate the risk of contamination. To safeguard patient health and lower the risk of healthcare-associated infections (HAIs), medical device manufacturers and healthcare providers need to maintain awareness to make sure that the devices are safe, sterile, and effective.

**COMPETING INTERESTS DISCLAIMER:**

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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