The Role of the OR Environment in Preventing Surgical Site Infections

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Hospital environments can be a source for the acquisition and spread of pathogens.[1-10] Pathogens are inherently present in the surgical setting, and several significant health care–associated pathogens can be transferred from patient to patient, from health care worker to patient or vice versa, and from surfaces to patients or health care workers and cause surgical site infections (SSIs). These pathogens (eg, methicillin-resistant *Staphylococcus aureus* [MRSA], *S aureus*, vancomycin-resistant enterococci, Acinetobacter species) may survive on environmental surfaces for weeks or months.[2,3] In fact, *Clostridium difficile* spores can persist on environmental surfaces for up to five months.[1] The increase in multidrug-resistant organisms is contributing to additional risk in the surgical setting. For example, MRSA and other drug-resistant pathogens cause serious and potentially life-threatening infections (eg, pneumonia, bloodstream infections, SSIs) and increase health care–associated infection (HAI) rates in health care facilities. Several studies demonstrated cross infection when a patient was admitted to a room from which a patient colonized or infected with these environmental pathogens was just discharged.[4,5] Recent research has identified a number of problems and associated strategies to mitigate infection concerns in the surgical setting. These strategies include using a bundled approach to decrease MRSA and HAI transmission rates, implementing measures to reduce the risk from airborne contaminants, expanding environmental cleaning protocols to address all surfaces in large hybrid ORs, implementing methods to decrease turnover time without increasing the risk of HAIs, implementing ultraviolent (UV) technology during terminal cleaning, and following the manufacturer's instructions for use (IFU) during instrument reprocessing in the sterile processing department.

STAPHYLOCOCCUS AUREUS AND OTHER MULTIDRUG-RESISTANT ORGANISMS

Staphylococcus aureus is considered to be the most significant pathogen associated with SSIs.[11] Epidemiological studies have shown that most SSIs are caused by strains of *S aureus* that are brought into the hospital environment by patients themselves.[12] Because *S aureus* is a significant cause of SSIs and is inherently present in the health care setting, the perioperative environment itself can be a potential risk factor for SSI. Because of this, environmental risk reduction strategies are key in helping protect patients from SSIs related to *S aureus* and other pathogens in the surgical setting.

In health care settings, MRSA can cause serious and potentially life-threatening infections, such as pneumonia, bloodstream infections, and SSIs. In 2007, the Veterans Administration implemented the MRSA Prevention Initiative (now called the MDRO Prevention Initiative), which resulted in

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significant decreases in the transmission of MRSA as well as decreases in HAI rates in hospitals.[13] Results showed a 17% decrease for intensive care units and 21% for non–intensive care units. The MDRO Prevention Initiative uses a bundled approach whereby health care providers

- use gowns and gloves when caring for patients colonized or infected with MRSA,
- clean rooms thoroughly with a low-linting cloth and Environmental Protection Agency–registered disinfectant products in the concentration indicated in the manufacturer's IFU,[14]
- isolate colonized or infected patients and their linens,
- implement and maintain an institutional culture that focuses on individual responsibility for infection control, and
- screen every patient undergoing high-risk surgery (eg, orthopedic, cardiac, implant procedures) for MRSA.[13]

AIRBORNE SOURCES OF WOUND CONTAMINATION

A number of studies have identified the airborne route as a significant exogenous source for intraoperative surgical wound contamination.[15-17] In addition, endogenous contamination can occur from the patient's own flora, either during surgery or during the postoperative period. Some strategies that have shown promise for reducing airborne contaminants include the use of

- laminar air flow ventilation,
- traffic control and limiting personnel in the OR,
- exhaust suits,
- surgical attire for complete hair and body coverage,
- smoke evacuators for procedures in which the electrosurgical unit or laser is used (eg, tissue ablation procedures), and
- UV lights to kill airborne contaminants.[15-17]

ENVIRONMENTAL CLEANING IN A HYBRID OR

Interest in hybrid ORs has grown in recent years, fueled by the rising demand for minimally invasive surgery and the ever more complex nature of interventional imaging. The term *integrative approach* in an OR is defined as a room in which all the different equipment is designed to work together in harmony, thus providing increased efficiency and better patient care. *Hybrid* is defined as a room serving both diagnostic and surgical functions in the same location. A hybrid OR is equipped with advanced medical imaging devices, such as a fixed fluoroscopy unit, computed tomography scanners, or magnetic resonance imaging scanners. Hybrid ORs, by their sheer size and the volume of equipment, pose a challenge for perioperative personnel with regard to infection prevention.

A traditional OR is approximately 600 to 700 square feet, whereas new hybrid rooms often are a minimum of 1,000 square feet, in addition to the space used as an equipment room and control room. Taking into account these separate rooms, the typical size is 1,200 square feet. Hybrid ORs also must accommodate two teams of clinicians, bridging two separate disciplines, resulting in as many as 26 people in the room at one time. In addition to being nearly double the size of typical ORs, hybrid ORs use more utilities, require shielding for the radiology equipment, and need structural support for the large equipment booms. These larger ORs have many exposed surfaces that must be cleaned and disinfected between procedures and terminally disinfected at the end of the day.

Environmental cleaning and disinfection is a team approach that should involve environmental department and perioperative personnel.[14-20] The perioperative nurse is responsible for ensuring a safe and clean environment before surgery by performing a visual inspection before case carts, supplies, equipment, and instruments are brought into the room.[14] This is especially important in hybrid ORs because of the large size and the increased time it takes to clean them compared with a standard OR. All horizontal surfaces in the OR should be damp dusted before the first scheduled surgical procedure of the day, which includes furniture, surgical lights, booms, and radiology

equipment. Plasma and monitor screens should be cleaned according to manufacturers' IFU.[14] Reduction in disinfectant time is important to process improvement teams as they attempt to decrease turnaround time in the OR and enhance surgical throughput. Some manufacturers have produced disinfectants that reduce the 10-minute contact time to two minutes.

SAFELY IMPROVING OR TURNOVER EFFICIENCY

An important concept in improving turnover times—and therefore improving efficiency and saving time and money for all perioperative team members—is creating multidisciplinary teams to clearly identify the roles associated with procedure setup and breakdown and determine which activities may safely be conducted simultaneously. Turnover times must be sufficient to allow personnel to thoroughly clean and disinfect surfaces that have come in contact with the patient or are visibly soiled (eg, blood, tissue) from the surgical procedure. Although reduction in turnover time is important for surgical throughput, this can be enhanced with the use of new disinfectants that require less contact time.

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Competent perioperative team members should participate in turning over the room, positioning the patient, placing the tourniquet, performing the surgical skin prep, holding limbs for prepping and positioning, connecting and disconnecting specialized equipment, preparing instruments and supplies for subsequent procedures, and assisting anesthesia team members with setup and breakdown. The more efficiently the multidisciplinary teamwork is managed, the faster the room turnover times will be.

By analyzing every task performed in room turnover and mapping out the process, perioperative personnel can more effectively assign tasks to everyone. Cleaning and disinfecting equipment should be easily accessible and ready to be used. Fast-drying disinfectants are now available for use in the OR, which decreases required contact times; some have reduced contact times of two to five minutes. Disposable, lint-free, single-use cloths immersed in germicidal containers can be used for cleaning during room turnover. Their use makes the wipe-down process more efficient. However, personnel must use as many cloths as necessary to ensure that an adequate quantity of the germicidal product comes in contact with every surface being cleaned for the appropriate dwell time (ie, the amount of time required for contact of a chemical agent with a surface) according to the manufacturer's IFU.

It may be possible to consider discontinuing the practice of routinely mopping floors between every procedure even when there was no possibility of splash or splatter of blood or body fluids, such as from irrigation. However, personnel must keep in mind that fluid contamination may have dried and may not always be visible. When there is any doubt, the traffic area should be mopped. It is the RN circulator's responsibility to make this decision on a case-by-case basis. Examples of procedures that may not require mopping the floor are pain injection or cataract procedures for which no irrigation is used and there is little, if any, risk of contaminating the floor with blood or other potentially infectious materials. Deciding not to mop the floor after this type of procedure could help decrease turnover time by eliminating the need to spend the time mopping the floor and allowing for the required disinfectant contact time.

Manufacturers of OR turnover equipment are assisting in this process by designing packaged kits with disposable linens, trash bags, hamper liners, kick bucket liners, wiping cloths, and mops designed to fit the unique needs of each hospital. These kits provide standardization of the process of room

turnover and help ensure the right equipment is accessible to clean and disinfect the room properly so turnover is expedited without compromising infection prevention efforts.

UV TECHNOLOGY DURING TERMINAL CLEANING

Research has shown that current strategies for terminal disinfection of hospital rooms are inadequate, and more than 50% of hospital surfaces may go untouched and uncleaned.[6,7] Therefore, hospitals are evaluating and using UV light in the C-band spectrum (UV-C) as a novel method to enhance terminal disinfection of hospital rooms and ORs. By deactivating DNA in bacteria, dust mites, viruses, and other pathogens, UV-C light is germicidal and destroys the ability of pathogens to multiply and cause disease. This process, however, does not naturally occur indoors. In one study, UV lighting appeared to be an effective way to lower the risk of infection in the OR during total joint replacement surgery.[8] Another study showed that UV-C light can effectively eradicate MRSA, vancomycin-resistant enterococci, Acinetobacter species, and *C difficile* under experimental conditions.[9] Another study confirmed that the automated UV-C emitter reduced the bioburden of MRSA, vancomycin-resistant enterococci, and *C difficile* in clinical settings.[10] As this technology further develops for practical use in the health care setting, room decontaminators that use UV-C light may be integrated into OR terminal disinfection processes to help reduce the risk of SSIs.

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STERILE PROCESSING PRACTICES

The increasing complexity of surgical instruments has complicated instrument cleaning processes. This poses increasing challenges for clinicians to adequately sterilize surgical instruments and perform high-level disinfection of endoscopes. Turnaround times are decreasing with surgical throughput to generate revenue. This can make the challenge even more complex for sterile processing department personnel. An outbreak of *Pseudomonas aeruginosa* related to improperly cleaned and sterilized arthroscopic shavers and cannulas occurred in a Texas hospital in 2009.[21] A cluster of seven organ-space SSIs caused by *P aeruginosa* occurred after arthroscopic procedures performed between April 22, 2009, and May 7, 2009. During the investigation that followed, investigators inspected the lumens of arthroscopic instruments by using a borescope (ie, a 3-mm clinical endoscope). The investigators then evaluated the arthroscope cleaning procedure. The process being followed at the facility involved briefly submersing the instrument in enzymatic solution, wiping down the instrument, and then processing the instrument with high-level disinfection, even though the manufacturer's IFU recommended gross decontamination with submersion in enzymatic solution for 10 to 15 minutes before low-temperature sterilization. The investigators inspected the instruments and discovered remnants of tissue and bioburden in each of the evaluated handpieces and the inflow/outflow cannula lumen after reprocessing. Bacterial contamination of surgical instruments likely survived the sterilization process because of residual tissue within the lumens of the arthroscopic instruments.

This outbreak prompted collaboration between the US Food and Drug Administration and Centers for Disease Control and Prevention to protect patients undergoing arthroscopic procedures. On July 7, 2009, the Food and Drug Administration released a Safety Alert regarding concerns about retained tissue within arthroscopic shavers despite reprocessing according to the manufacturer's recommendations.[22] This outbreak and others also have led to increased scrutiny in the sterile processing

department during surveys by The Joint Commission and Centers for Medicare & Medicaid Services.

One of the most important practices associated with reprocessing complex surgical instruments is following the manufacturer's IFU and making sure they are available in the area where the instruments will be reprocessed, whether that is the sterile processing department or the OR. The manufacturer's IFU provide detailed information related to critical reprocessing elements such as brush type, water temperature, and enzymatic solution, as well as detailed cleaning procedures. Many national organizations, including the Association for the Advancement of Medical Instrumentation[23] and AORN,[24] recommend following the manufacturer's IFU. AORN recommends that devices should be cleaned, decontaminated, inspected, packaged, sterilized, and stored in a controlled environment in accordance with the manufacturer's written IFU.[24] In addition, AORN recommends that the manufacturer's IFU for handling and reprocessing should be obtained and evaluated before purchasing surgical instruments to ensure that the equipment can be cleaned and reprocessed in the health care facility.[24,25]

PERIOPERATIVE NURSING IMPLICATIONS

Perioperative nurses play a vital role in helping to ensure a clean and safe environment in the surgical suite. In addition to practicing good hand hygiene, perioperative personnel must address potential infection issues caused by having patients in the preoperative holding area who require isolation precautions; the environment must be thoroughly cleaned and disinfected between each patient. Daily routine cleaning of the environment is a shared endeavor between perioperative and environmental department personnel. In the OR, RN circulators ensure that room turnover is performed properly and terminal cleaning is performed on a daily basis. All equipment being brought into an OR has to be wiped down with a disinfectant to remove dust and contaminants. In the postanesthesia care unit, nurses ensure that the environment is kept clean and personnel disinfect bedside tables and other equipment between patients. Infection control and prevention in the perioperative setting requires teamwork to help ensure a clean environment.

CONCLUSION

The most important prevention measure is simple hand hygiene, but many factors contribute to the development of an SSI. Infection prevention is everybody's responsibility, including surgeons, perioperative nurses, anesthesia professionals, and ancillary personnel. Thus, strong teamwork is essential in making surgery safe for patients. The formation of a multidisciplinary team is essential to address the following factors:

- Strive to eliminate all pathogens from the perioperative environment with use of state-of-the-art cleaning products and strict adherence to evidence-based processes.
- Use varied strategies to reduce airborne contaminants in the perioperative environment.
- Evaluate the use of UV-C light to enhance terminal disinfection of ORs.
- Ensure that manufacturer's IFU are followed when reprocessing complex surgical instruments.

It takes teamwork, leadership, accountability, and commitment to make the OR a safe environment that is free of exogenous contaminants and to ensure that personnel adhere to aseptic techniques and practices. AORN

References

1. Kim KH, Fekety R, Batts DH, et al. Isolation of *Clostridium difficile* from the environment and contacts of patients with antibiotic-associated colitis. *J Infect Dis.* 1981;143(1):42-50.
2. Neely AN, Maley MP. Survival of enterococci and staphylococci on hospital fabrics and plastic. *J Clin Microbiol.* 2000;38(2):724-726.
3. Weber DJ, Rutala WA. Role of environmental contamination in the transmission of vancomycin-resistant enterococci. *Infect Control Hosp Epidemiol.* 1997;18(5):306-309.
4. Datta R, Platt R, Yokoe DS, Huang SS. Environmental cleaning intervention and risk of acquiring multidrug-resistant organisms from prior room occupants. *Arch Intern Med.* 2011;171(6):491-494.
5. Huang SS, Datta R, Platt R. Risk of acquiring antibiotic-resistant bacteria from prior room occupants. *Arch Intern Med.* 2006;166(18):1945-1951.

6. Carling PC. Evaluating the thoroughness of environmental cleaning in hospitals. *J Hosp Infect.* 2008;68(3):273-274.
7. Carling PC, Parry MF, Von Beheren SM. Identifying opportunities to enhance environmental cleaning in 23 acute care hospitals. *Infect Control Hosp Epidemiol.* 2008;29(1):1-7.
8. Ritter MA, Olberding EM, Malinzak RA. Ultraviolet lighting during orthopaedic surgery and the rate of infection. *J Bone Joint Surg Am.* 2007;89(9):1935-1940.
9. Nerandzic MM, Cadnum JL, Pultz MJ, Donskey CJ. Evaluation of an automated ultraviolet radiation device for decontamination of *Clostridium difficile* and other healthcare-associated pathogens in hospital rooms. *BMC Infect Dis.* 2010;10:197.
10. Boyce JM, Havill NL, Moore BA. Terminal decontamination of patient rooms using an automated mobile UV light unit. *Infect Control Hosp Epidemiol.* 2011;32(8):737-742.
11. Sievert DM, Ricks P, Edwards JR, et al. Antimicrobial-resistant pathogens associated with healthcare-associated infections: summary of data reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2009-2010. *Infect Control Hosp Epidemiol.* 2013;34(1):1-14.
12. Sexton T, Clarke P, O'Neill E, Dillane T, Humphreys H. Environmental reservoirs of methicillin-resistant *Staphylococcus aureus* in isolation rooms: correlation with patient isolates and implications for hospital hygiene. *J Hosp Infect.* 2006;62(2):187-194.
13. Jain R, Kralovic SM, Evans ME, et al. Veterans Affairs initiative to prevent methicillin-resistant *Staphylococcus aureus* infections. *N Engl J Med.* 2011;364(15):1419-1430.
14. Recommended practices for environmental cleaning. In: *Perioperative Standards and Recommended Practices*. Denver, CO: AORN, Inc; 2014:255-276.
15. Edmiston CE, Seabrook GR, Cambria RA, et al. Molecular epidemiology of microbial contamination in the operating room environment: is there a risk for infection? Presented at the 62nd Annual Meeting of the Central Surgical Association; Tucson, AZ; March 10-12, 2005.
16. Whyte W, Hodgson R, Tinkler J. The importance of airborne bacterial contamination of wounds. *J Hosp Infect.* 1982;3(2):123-135.
17. Lidwell OM, Lowbury EJ, Whyte W, Blowers R, Stanley SJ, Lowe D. Airborne contamination of wounds in joint replacement operations: the relationship to sepsis rates. *J Hosp Infect.* 1983;4(2):111-131.
18. Allen G. Implementing AORN recommended practices for environmental cleaning. *AORN J.* 2014;99(5):570-582.
19. Spruce L. Back to basics: environmental cleaning. *AORN J.* 2014;100(1):54-64.
20. Jefferson J, Whelan R, Dick B, Carling P. A novel technique for identifying opportunities to improve environmental hygiene in the operating room. *AORN J.* 2011;93(3):358-364.
21. Tosh PK, Disbot M, Duffy JM, et al. Outbreak of *Pseudomonas aeruginosa* surgical site infections after arthroscopic procedures: Texas, 2009. *Infect Control Hosp Epidemiol.* 2011;32(12):1179-1186.
22. Arthroscopic shavers: ongoing safety review [archived content]. US Food and Drug Administration. http://www.fda.gov/Safety/MedWatch/SafetyInformation/SafetyAlertsforHumanMedicalProducts/ucm170730.htm. July 7, 2009. Updated July 7, 2009. Accessed September 19, 2014.
23. Association for the Advancement of Medical Instrumentation. *ANSI/AAMI ST79:2013—Comprehensive Guide to Steam Sterilization and Sterility Assurance in Health Care Facilities*. Arlington, VA: Association for the Advancement of Medical Instrumentation; 2013.
24. Recommended practices for sterilization. In: *Perioperative Standards and Recommended Practices*. Denver, CO: AORN, Inc; 2014:575-602.
25. Recommended practices for cleaning and care of surgical instruments and powered equipment. In: *Perioperative Standards and Recommended Practices*. Denver, CO: AORN, Inc; 2014:541-560.

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