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Surgical Site Infections: Anesthesia Professionals Can Help Get Us on a Path to Zero

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Approximately 2 million hospitalized patients develop health care-associated infections (HCAI) annually, contributing to over 90,000 deaths each year in the United States (*J Am Coll Surg* 2017;225:455-64). While the source of these infections is complex and often multidimensional, the consequences are clear and often serious. They include increased costs, selection pressure for drug-resistant organisms, patient and family dissatisfaction, and even potential liability. Surgical site infections (SSIs) are especially relevant to the anesthesiology community, as they account for 20% of all HCAI. Indeed, SSIs afflict 1%-3% of all surgical patients, increasing the hospital LOS from three to 10 days and increasing mortality two- to 10-fold (*J Am Coll Surg* 2017;225:455-64). Importantly, the majority of SSIs are considered preventable. Therefore, the Anesthesia Patient Safety Foundation (APSF) has identified prevention of perioperative infections as one of their top 11 patient safety priorities. But how do we get to zero SSI?

First, we need to recognize the perioperative arena, most notably the ORs, consolidates three key components – patients, the medical environment, and health care providers. In particular, the hands of health care providers are conducive to SSIs by creating the intimate lateral proximity necessary for cross-transmission of organisms. Patients are naturally colonized with both pathogenic and non-pathogenic organisms on their skin, in their nose and mouth, the airways, and the gastrointestinal tract. These organisms can readily contaminate health care workers' hands, the hospital environment, medical equipment, and even other patients who will eventually be in the same OR and likely be taken care of later by the same anesthesia provider. This can create a medical vicious cycle (Figure 1) in spreading bacteria and infections. ORs accommodate multiple patients each day with an even larger influx of surgical and anesthesia team members. In the confined space of the OR, anesthesia professionals regularly touch patients, devices (e.g., I.V. hubs), environmental surfaces, and equipment at a high rate, often with limited opportunity to perform optimal hand hygiene (*Anesth Analg* 2015;120:703-5) but ample opportunity for cross contamination. Indeed, anesthesia professionals interact with their environment and patients very frequently (*Infect Control Hosp Epidemiol* 2014;35:1056-9). During eight hours of OR observation, the anesthesia professional touched surfaces 1,132 times, completed 66 stopcock injections, and inserted four vascular catheters (*Infect Control Hosp Epidemiol* 2014;35:1056-9; *Anesthesiology* 2016;124:785-94). Infectious risks and some proposed interventions will be discussed for each of the major components of the contamination "merry-go-round" (Figure 1).

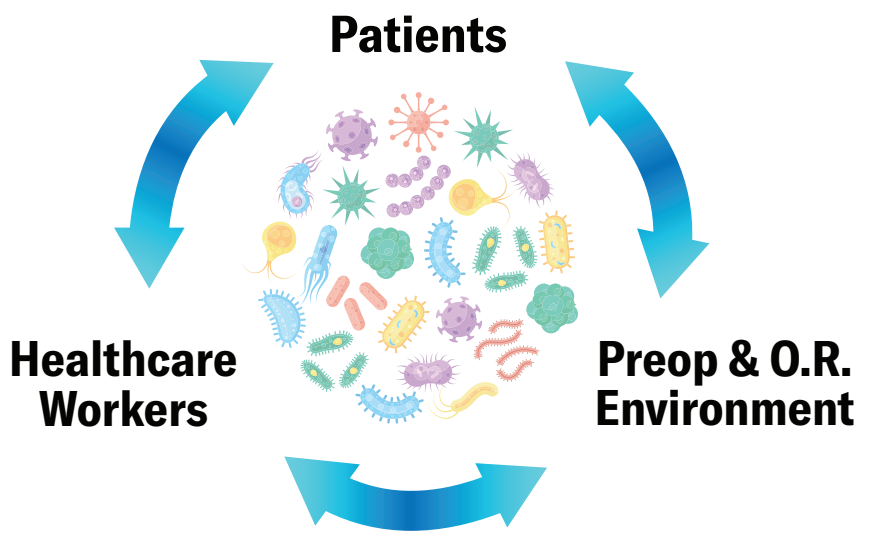

Figure 1: The invisible "Merry-Go Round" of the three necessary components (patients, the perioperative environment, and health care workers' hands) for organism transmission before and during surgery. In the confined space of the OR, anesthesia professionals touch patients, syringes and I.V. injection hubs, environmental surfaces, and airway equipment at a high rate that likely contributes to surgical site infections in 1%-3% of patients.

Modified from Munoz-Price LS, Weinstein RA. Fecal Patina in the Anesthesia Work Area. *Anesth Analg*. 2015;120:703-705.

Health care workers' hands

The Society for Healthcare Epidemiology of America (SHEA) collaborated with ASA, the APSF, Association of periOperative Registered Nurses (AORN), and the American Association of Nurse Anesthetists (AANA) to form a task force to publish vital infection control guidance for the anesthesia work area (*Infect Control Hosp Epidemiol* 2018;40:1-17). This guideline, with input from participants representing key organizations, was designed to provide practical and evidence-based practices with implementation strategies. The authors of the review were members of the task force, which also included epidemiologists, infectious disease experts, a surgeon, and nurse anesthetists.

Figure 2: Intraoperative photograph of the anesthesia work surface during the maintenance phase of a routine general anesthetic. Note two medication syringes are uncapped (circled highlights) while in close proximity to the patient's previously used airway equipment.

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The key recommendations include:

Hand hygiene: Bacteria counts on the hands range from 40,000 to 4 million colony-forming units per square centimeter (asamonitor.pub/3871Gl4). These organisms consist of both long-term resident and transient flora (i.e., those most commonly responsible for HCAI). Therefore, hand hygiene should be performed, at a minimum, before aseptic tasks, after removing gloves, when hands are soiled, before touching the anesthesia cart, and upon OR room entry and exit

(*Anesth Analg* 2019;129:1446-9). The SHEA Task Force as well as the APSF strongly believe that anesthesia professionals are critical in finding a "path to zero." Thus, there must be strategic and convenient placement of alcohol-based hand rub (ABHR) dispensers, including within the OR itself. Clinicians may encounter misguided concerns over the potential flammability of ABHR used in the OR environment. The National Fire Protection Association (NFPA) has recently published the 2018 Codes and Standards, which specifically address the appropriate use and placement of ABHR dispensers to mitigate concerns about flammability used in this context (National Fire Protection Association. 2018). Clearly, ABHR should be available immediately inside and outside of every OR and anesthetizing site.

Special precautions at times of airway management: At times of intubation, extubation, or manipulation of the airway, the use of double gloves is endorsed so that the outer layer can be removed when contamination is likely and subsequent care demands preclude optimal hand hygiene (*Anesth Analg* 2019;129:1446-9; *Anesth Analg* 2015;120:848-52). Even the practice of "foaming gloves" with ABHR may be considered. The report also recommends high-level disinfection of reusable laryngoscope handles and consideration of single-use laryngoscopes.

Pre-op and OR environment

For environmental disinfection, the SHEA guidance recommends disinfecting high-touch surfaces on the anesthesia machines as well as keyboards, monitors, and other items in work areas in between surgeries, while also exploring the use of disposable covers and re-engineering of the work surfaces to facilitate and maintain effective decontamination.

Contamination of OR surfaces has been demonstrated both through environmental cultures and the use of fluorescent markers (*Anesth Analg* 2015;120:844-7; *AORN J* 2011;93:358-64). These markers are transparent gels visible only under ultraviolet light. Using this technique, Birnbach et al. reported how the hands of anesthesia providers quickly contaminate the local anesthesia environment within minutes of induction of anesthesia and endotracheal intubation (*Anesth Analg* 2015;120:848-52). In addition, there is compelling evidence of contamination of used and unused syringes present on the working surface of the anesthesia machine (illustrated in Figure 2) (*Anesthesiology* 2008;109:399-407). Laryngoscope blades or handles placed on the clean surface with unused syringes may similarly be a route of contamination. Figure 3 shows the contamination of a laryngoscope handle after use on a mannequin with fluorescent gel (DAZO, Ecolab, St. Paul, MN) placed in the mouth.

One fluorescence study reported a 100% contamination of the I.V. hub, anesthesia circuit, and anesthesia cart (*Anesth Analg* 2015;120:844-7). Indeed, peripheral I.V. tubing stopcocks and injection ports that are used for medication administration frequently become contaminated with potentially pathogenic bacteria during intraoperative clinical use. I.V. drug injection recommendations include that injection ports and vial stoppers should only be accessed after appropriate disinfection with a sterile alcohol-based disinfectant wipe using a vigorous friction-motion for at least 15 seconds. Numerous "Scrub the Hub" campaigns have proven somewhat successful in reinforcing the message that a prolonged and vigorous scrub is necessary prior to medication injections. The necessity of the proper duration of proper disinfecting practices is illustrated in Figure 4. But an alternative may be to attach sterile isopropyl alcohol-containing caps that cover ports continuously (such as Curosä disinfecting port protectors by 3M). It is well recognized that a higher number of I.V. medication injections and hub interactions increases the probability of contamination (*Anesth Analg* 2015;120:844-7; *AORN J* 2011;93:358-64; *Anesthesiology* 2008;109:399-407).

Patients

Healthy ambulatory people may be non-, intermittent, or persistent carriers of potential pathogens such as *Staphylococcus aureus*. Moreover, colonization of multiple body sites (e.g., skin and nares) is the norm.

Figure 3: Image showing contamination of a laryngoscope handle on the anesthesia machine after use during a simulated induction on a mannequin with fluorescent gel placed in the mouth as a proxy for oral microorganisms.

Surveillance indicates that 15%-30% of patients presenting for elective surgery are nasally colonized with methicillin-sensitive *Staphylococcus aureus* (MSSA), and 1%- 3% are colonized with methicillin-resistant *S. aureus* (*Infect Dis Clin North Am* 2021;35:107-33). Unique populations such as patients undergoing routine renal dialysis are at increased risk of *Staphylococcal* colonization.

"As noted by the World Health Organization, 'Clean Care is Safer Care' and is a basic right."

Two strategies are proposed to suppress or eliminate *Staphylococcus* organisms before elective surgery. While current data do not support a universal approach (whereby every patient undergoes suppressive therapy before every surgery), most current evidence suggests a *targeted* approach is optimal whenever patients screen positive for *S. aureus* or in those who are at exceptional risk from SSIs. Given that colonization of multiple body sites (e.g., skin and nares) is the norm, preoperative *S. aureus* decolonization relies on the combination of chlorhexidine gluconate showers or wipes and nasal decontamination, often with mupirocin. Use of 5% povidone-iodine nasal solution is becoming common because of increasing resistance to mupirocin. Both nasal mupirocin and 5% povidone-iodine USP maintain a significant reduction (>99%) in the bacterial load for up to 12 hours (*Am J Infect Control* 2019;47S:A53-57). These techniques already have proven efficacy with improved outcomes in both orthopedic and cardiac surgery patients (*Infect Control Hosp Epidemiol* 2014;35:826-32).

In summary, the OR environment has the potential to be one of the most contaminated areas in the hospital (*Infect Control Hosp Epidemiol* 2012;33:897-904). SHEA guidance (*Infect Control Hosp Epidemiol* 2018;40:1-17) provides numerous additional recommendations that should be incorporated into anesthesia practice to help decrease patient-related infectious risks. Additionally, similar infection control guidelines with SSI care bundles have been published. Each surgical and anesthesiology department should assess their individual circumstances and implement best practices commensurate with their ORs and patient population. As noted by the World Health Organization, "Clean Care is Safer Care" and is a basic right. ■

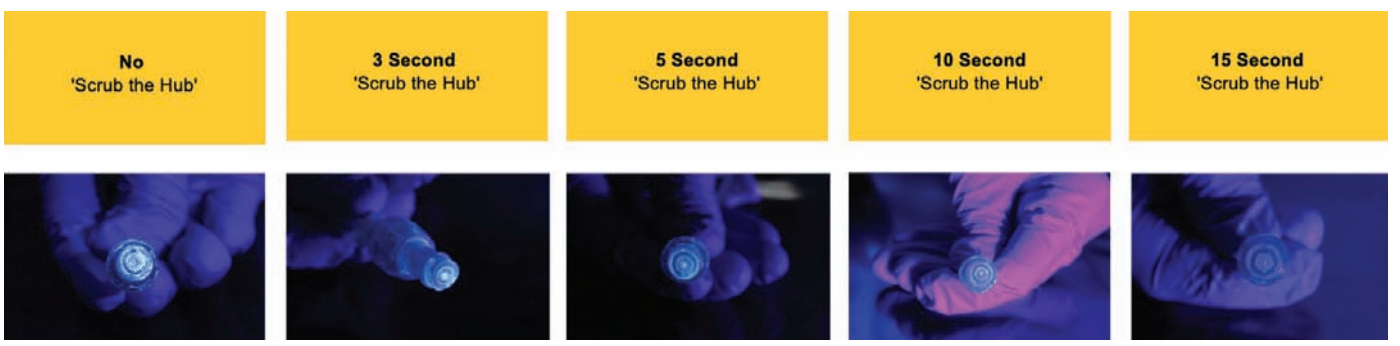

Figure 4: Contamination of the needleless connector hub of I.V. catheters is simulated with the novel use of a fluorescent marker dye. These dyes are transparent gels that are invisible under normal lighting but become highly visible under ultraviolet light. Our simulation reinforces the mantra that at least 15 seconds of a vigorous scrub with 70% alcohol is required for adequate cleaning of the hub.

Disclosure:
Dr. Prielipp reports lectures for Merck Co., Inc., and consultations for 3M (Minneapolis).