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Patient Safety in Anesthesia: Hand Hygiene and Perioperative Infection Control

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Abstract

Purpose of Review This review highlights the importance of the anesthesia team in minimizing perioperative infection risks and prevention of surgical site infection. Due to the immense financial and patient care burden that results from perioperative infection, a foundational knowledge in preventive measures is essential.

Recent Findings Perioperative infection control, the role of the anesthesia team in reducing infection risk, and more specifically the outsized importance of hand hygiene in this space have become increasingly apparent. Maintenance of workspace cleanliness along with hand hygiene forms the cornerstone of preventing microbial transmission. Unfortunately, improvements around perioperative infection control are lacking.

Summary The importance of the anesthesia team in maintaining proper hand hygiene, a clean work environment, and appropriate patient conditions to minimize risk of perioperative infection cannot be overstated. Poor clinical outcomes, economic burden, and external pressure from payers highlight the need for anesthesia providers to have an up-to-date knowledge of best practices in this area. In this article, we will review the current recommendations for hand hygiene practices and perioperative infection prevention.

Keywords Hand hygiene · Infection control · Surgical site infection · Healthcare-associated infection

Introduction

Hand hygiene (HH) and its importance in the reduction of perioperative infection risk in the hospital setting is foundational to anesthesia providers [1]. Recent evidence suggests that the anesthesia care team has a vital role in minimizing this risk by limiting transmission of infectious flora through HH and clean workspaces, appropriate and timely prophylactic antibiotic administration, as well as maintaining adequate patient physiologic conditions: normothermia, glucose management, etc. [2–4]. In a randomized controlled trial (RCT), Loftus et al. demonstrated that basic preventive measures can significantly reduce transmission, and therefore infections, of *Staphylococcus aureus* [3]. As a follow-up to this RCT, Wall et al. evaluated the feasibility and effectiveness of these preventive measures in reducing transmission of *S. aureus* and subsequent surgical site infections (SSI) [4]. Results provided conclusive evidence that implementing basic preventive measures was both feasible and effective and should be a part of the routine care provided by anesthesia staff.

Due to the economic burden as well as patient quality of life factors related to perioperative infections, exploring methods to increase HH compliance, and ultimately reduce perioperative infection, is of utmost importance to hospital administration and clinicians [5]. In comparison to the tremendous financial costs associated with healthcare-associated infections (HAI), HH compliance is a cost-effective means of improving quality with minimal added cost [6].

In this comprehensive review, background information related to the current HAI and SSI demographics will be

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provided. Additionally, currently accepted HH practices and more specifically, perioperative infection control practices are described. Lastly, HH practices will be explored outside of operating rooms (ORs) and in commonly utilized clinical locations, such as pre-operative holding areas for regional anesthesia, and labor and delivery suites.

Implications and Demographics of Perioperative-Associated Infections

An HAI is defined as any infection that occurs between 48 h and 30 days after a patient is hospitalized or receives healthcare [7]. HAIs are a significant cause of morbidity and mortality for patients receiving medical care in the USA, affecting 4–10% of all hospitalized patients, accounting for over 700,000 infections and ~ 99,000 deaths per year [8–11]. The COVID-19 pandemic has also had an interesting effect on HAIs and the development of multidrug-resistant organism (MDR) infections. Data from several countries during the pandemic showed an overall decline in rates of MDR isolated in their hospitalized patients, possibly owing to increased adherence to HH, personal protective equipment (PPE), and social distancing [12–19].

Of all HAIs, the most frequent offenders include catheter-associated urinary tract infections (CAUTIs), hospital-acquired pneumonias (HAPs), bloodstream infections (BSIs), and surgical site infections (SSIs) [20]. The Centers for Disease Control and Prevention (CDC) defines an SSI as an infection in an incision, organ or organ space manipulated during an operation that occurs within 30 days of surgery or within 90 days of surgery if there is an implanted prosthesis [21].

The most common organisms causing HAIs are *Enterococcus*, *Staphylococcus aureus*, *Klebsiella*, *Acinetobacter*, *Pseudomonas*, and *Enterobacter* spp. (ESKAPE) [22].

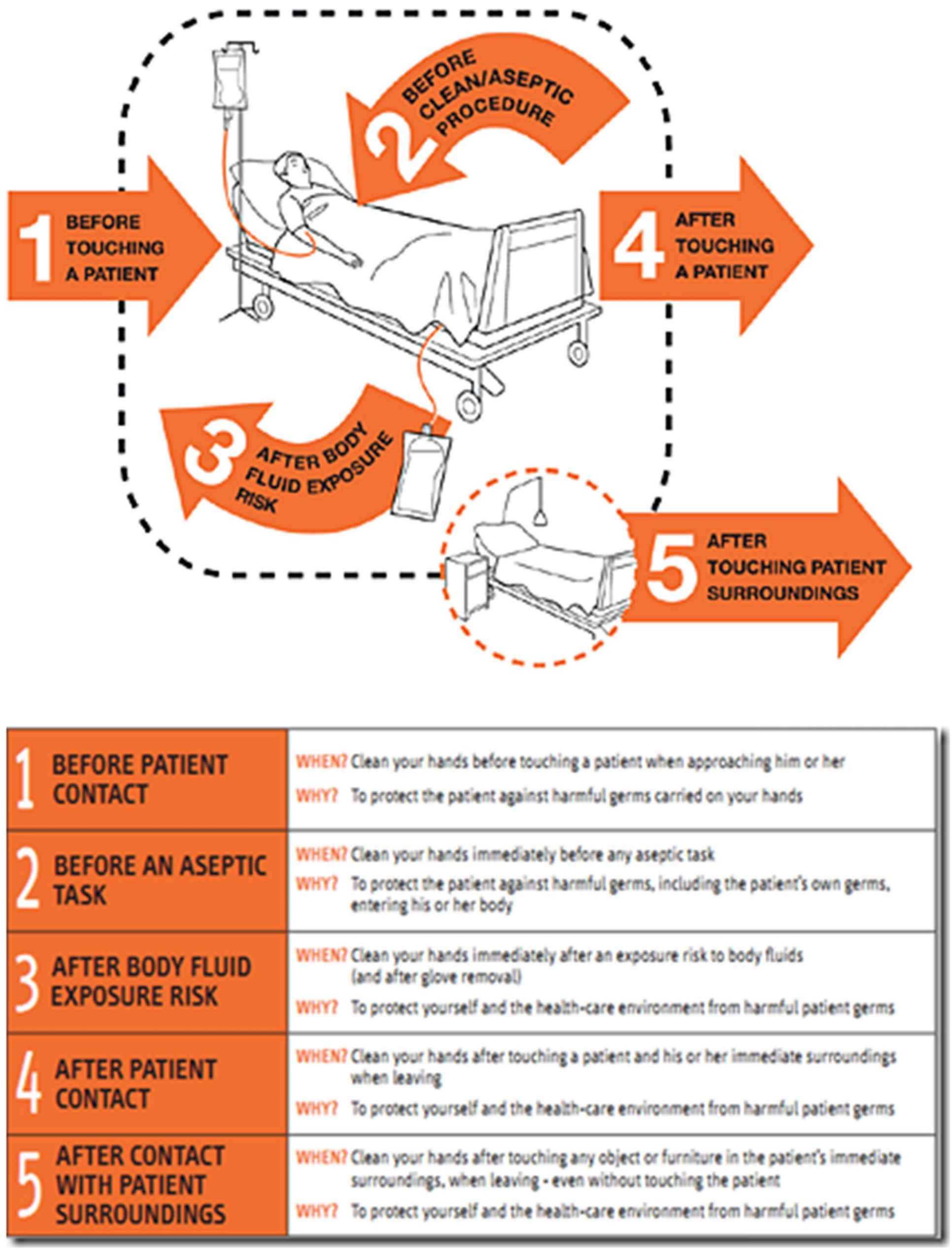
Frequent treatment of these commonly implicated organisms has led to increasing resistance and the rise of MDR infections, a worrisome trend. Methicillin-resistant *Staphylococcus aureus* (MRSA) is thought to be the most common organism that causes SSIs in the USA [23]. Along with other types of MDR such as vancomycin-resistant enterococci (VRE), MRSA is resistant to more antibiotics than what its name implies, leading to increased treatment challenges [24]. Every year, more than 2 million people will be infected with a MDR, and 23,000 of those people will die from their infection [25, 26]. A patient's in-hospital mortality increases twofold when they develop a MDR infection, with *Klebsiella pneumoniae* and *Escherichia coli* being the most common causative organisms [27, 28]. Additionally, gram-negative bacterial infections, from an organism such as *Klebsiella pneumoniae* and *Escherichia coli*, account for 70% of all intensive care unit (ICU) HAIs and up to 40% of all ICU deaths [12].

While the fight against HAIs and MDRs is multi-factorial, the World Health Organization (WHO) and CDC have recognized HH as a primary prevention strategy [29, 30]. Despite the important role that HH plays in the battle to prevent HAIs, health care workers and anesthesia providers remain woefully inadequate in their HH compliance at less than 50% and 23%, respectively [31]. This issue was highlighted in a survey of anesthesia providers' knowledge regarding HH, establishing the deficiency in anesthesia providers' ability to recognize the importance of, as well as the opportunities to perform, proper hand hygiene [32].

Role of the Anesthesia Care Team in Reducing Bacterial Infection Transmission

The responsibility of anesthesia providers in combatting HAIs in surgical patients goes beyond the timely administration of antibiotics. Efforts must be made to protect patients from environmental exposure of bacteria within the operating room (OR) as well as preventing anesthesia providers from becoming vectors for intraoperative bacterial transmission. Research shows that contamination of the anesthesia work area is both rapid and widespread. Birnbach et al. found that after a 6-min simulated intubation sequence where a fluorescent dye was placed in the mannequin's oral cavity, there was dye present on IV hubs in 100% of the scenarios, in addition to the medication syringes, anesthesia keyboard, and OR door handle in the majority of cases [33]. Other studies have evaluated how this cross-contamination affects patient care and outcomes. Loftus et al. found that there is an overall increase in bacterial contamination during the administration of general anesthesia, which led to IV stopcock contamination in 32% of cases, an increase in postoperative VRE sepsis, and an increase in mortality [34]. The same author concluded in a subsequent study that as many as 16% of 30-day postoperative infections were caused by bacterial transmission from the anesthesia work area [8].

Given the hands-on nature of clinical anesthesia, and the high level of task density asked of the anesthesia team, the frequency of indications for hand hygiene can be > 300 times per hour in accordance with the WHO 5 moments for hand hygiene [35] (Fig. 1). As task density increases, the need for more frequent HH increase proportionally. Frequent HH requirements, combined with the acute, dynamic nature of the OR environment, has led to non-adherence rates for hand hygiene of 83% [36]. The need for regularity of performing HH in the anesthesia work area (AWA) generates a need



1 BEFORE PATIENT CONTACT	WHEN? Clean your hands before touching a patient when approaching him or her WHY? To protect the patient against harmful germs carried on your hands
2 BEFORE AN ASEPTIC TASK	WHEN? Clean your hands immediately before any aseptic task WHY? To protect the patient against harmful germs, including the patient's own germs, entering his or her body
3 AFTER BODY FLUID EXPOSURE RISK	WHEN? Clean your hands immediately after an exposure risk to body fluids (and after glove removal) WHY? To protect yourself and the health-care environment from harmful patient germs
4 AFTER PATIENT CONTACT	WHEN? Clean your hands after touching a patient and his or her immediate surroundings when leaving WHY? To protect yourself and the health-care environment from harmful patient germs
5 AFTER CONTACT WITH PATIENT SURROUNDINGS	WHEN? Clean your hands after touching any object or furniture in the patient's immediate surroundings, when leaving - even without touching the patient WHY? To protect yourself and the health-care environment from harmful patient germs

Fig. 1 WHO 5 moments of hand hygiene

for conveniently located alcohol-based hand rub (ABHR) (Fig. 2). Several studies have found that wearable ABHR led to increased overall usage and better adherence to proper hand hygiene protocols [37, 38]. A similar study found that the wearable ABHR device increased the hourly decontamination events by 27-fold, as well as a reduction in bacterial transmission to stopcocks, AWA contamination, and 30-day postoperative HAIs [39]. When looking at the same wearable ABHR devices utilized in the ICU, there was a reduction in ventilator-associated pneumonias, further exemplifying the critical role of proper HH in the prevention of bacterial transmission in acute care environments [40]. In addition to improved access to ABHR and appropriate HH protocols, other techniques, such as double gloving during intubation with immediate doffing of contaminated gloves, have shown promise in reducing bacterial transmission during anesthesia [41]. While factors such as enhanced environmental decontamination, proper care of intravascular access points, and patient decolonization have shown value in the battle against SSIs, there is robust data, a randomized clinical trial and large post-implementation analysis, showing that improvement in HH awareness and behaviors among anesthesia providers can substantially reduce the incidence of *S. aureus* transmission and SSIs [42].

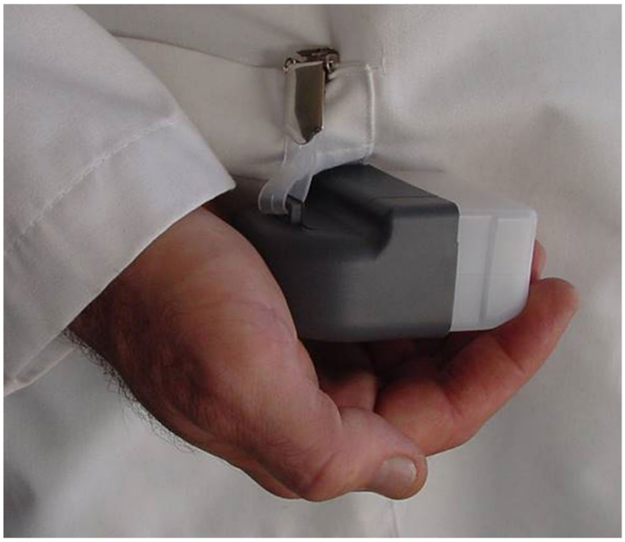


Fig. 2 Example of wearable alcohol-based hand rub device

Economic Impact of SSI and HAI

The economic burden of HAIs is immense, with estimated direct costs between $28 and $45 billion annually, in the USA [43]. This number is a gross underestimate of total costs as it does not include indirect costs associated with lost wages and productivity, mortality, lost leisure time, etc. Yet the overall cost of HH compliance is low [44] and the costs to patients and healthcare systems, resulting from non-compliance, are high [45]. Chen et al. demonstrated that for every $1 spent on HH promotion there was a resultant $23.70 of benefit [44]. Additionally, prevention of HAIs results in significant cost savings with even a 1% increase in HH compliance at a 200-bed hospital resulting in an annual savings of $39,650 [45].

Healthcare value, defined as (Value = Quality/Cost) is negatively correlated to HAI with patient's experiencing a decreased quality with respect to increased mortality and pain, as well as a decreased quality of life and satisfaction [46–48]. Health insurance companies have taken note of the increased costs related to HAIs, and there has been a trend towards lower reimbursements to hospitals if the patient develops a HAI. This shift in compensation has led to a reduction in the rate of HAIs, and lowered the probability of contracting an HAI within the 3 years after this policy change took effect [49]. Although accounting for only about 20% of all HAIs, SSIs are considered the costliest type of HAI. On average, SSIs extend the patient's hospital length of stay by 9.7 days and increase the hospitalization cost by more than $20,000 per admission. Additionally, SSIs are associated with a 2- to 11-fold increased risk of mortality with 75% of SSI-associated deaths being directly linked to the SSI [50, 51]. All of these factors pressure healthcare systems and hospital administration to seek methods to improve HH compliance, reduce perioperative infection risk, and subsequently improve patient outcomes [52].

Current Practices for Perioperative Infection Control

Although the rate of surgical site infections (SSIs) has declined significantly in the past decade, SSIs remain some of the most common and costly healthcare-associated infections [53]. The Centers for Disease Control and Prevention emphasize improved basic preventive measures to reduce bacterial infections in patients undergoing surgery [54]. Common pathogens associated with SSIs include *Staphylococcus aureus*, coagulase-negative staphylococci, *Enterococcus*, and *Escherichia coli* [55]. Different institutions have various practice parameters with regard to their strategy for perioperative infection prevention, and usually some degree of overlap is seen in implementation and compliance in various places. In a study performed at the University of Iowa, a perioperative infection prevention bundle that incorporated a multimodal program targeting parallel improvements in hand hygiene, intravascular catheter disinfection, environmental cleaning, and patient decolonization optimized by OR PathTrac surveillance feedback was pursued to address the complex interplay of intraoperative bacterial reservoirs [3, 56]. Most institutions around the nation should pursue a similar strategy, with institutional caveats and modifications, to combat perioperative infections (Table 1).

Hence, a multimodal, evidence-based, multifaceted approach for perioperative infection prevention, with proven contributions to transmission and infection, including patient skin sites, environmental sites, hands, intravascular catheter injection ports, and syringe tips, with a surveillance system for providing ongoing feedback, is likely to reduce perioperative transmission.

Current Recommendations for Hand Hygiene

WHO first published *Guidelines on Hand Hygiene* in 2006, and this thorough review was accompanied by recommendations to prevent the transmission of pathogenic organisms between patients and healthcare workers [63]. The review and recommendations can be distilled to the World Health Organization's five moments of hand hygiene (Fig. 1). The first moment being prior to any physical contact with patients and with the goal of protecting patients from harmful microorganisms on healthcare practitioners' hands. HH utilization here aids in preventing colonization of patients and their surroundings by healthcare-associated microorganisms.

Table 1 Steps detailing the use of a multimodal perioperative infection control bundle

	Interventions	Details
1	Hand hygiene	Making sanitizer dispensers easily available near the anesthesia machine and re-education of providers about their use [39]
2	Organization of the anesthesia work area	Separate "dirty" and "clean" areas are designated. A wire basket lined with a plastic bag is placed on the IV pole to serve as a receptacle for contaminated equipment [57]
3	Frequency and quality of environmental cleaning	Surface disinfection wipes, containing a quaternary ammonium compound and isopropyl alcohol, are used to clean the anesthesia machine following induction of anesthesia [58]
4	Intravascular catheter and syringe tip disinfection	Use of disinfection caps containing 70% isopropyl alcohol that can disinfect in 10 s and with 1 turn [59]
5	Patient decolonization with nasal povidone iodine	Nasal povidone iodine reduces risk of SSI by treating *Staphylococcus aureus* colonization [60]
6	Targeted ultraviolet UV-C light therapy	Terminal cleaning procedures, by using targeted UV-C therapy, are used to decontaminate OR environments [61]
7	Quarterly feedback via surveillance failure mode analysis	Surveillance unit reservoirs contributing to *S. aureus* transmission events are identified, and this information is used to generate typical transmission maps, revealing areas where further targeted approaches need to be employed (feedback-based intervention) [62]

Second, HH should precede any clean or aseptic procedure to protect patients at greater risk of transmission of pathogens secondary to disruption of surface tissues. These harmful microorganisms may be located both within and outside the patient zone. Healthcare practitioners may encounter contaminated surfaces within the patient zone without ever touching the patient. Third, HH should commence after any exposure to body fluid, or risk of exposure, since this protects the healthcare worker and the healthcare environment from potentially harmful patient microorganisms, reduces the colonization by organisms of healthcare workers, inhibiting the transmission from a colonization location to a clean location. The fourth moment directs HH after any contact with a patient, preventing health care workers and the healthcare environment from acting as vectors. This should specifically occur, if possible, during the transition from the patient zone to outside to avoid contamination and dissemination to the greater healthcare environment. And finally, HH should be completed after contact with the patient's surroundings again to protect the healthcare practitioner and environment from harmful microbes in the patient zone.

Additional Perioperative Situations

Regional anesthesia techniques, including peripheral nerve blocks and neuraxial anesthesia, are very common in modern anesthesiology practice and introduce additional considerations for HH. Fortunately, infectious complications of peripheral nerve blocks and neuraxial anesthesia are quite rare [64]. Clinical practice guidelines recommend the use of WHO's five moments of hand hygiene when performing a regional technique. Barriers to HH compliance are similar to those experienced in other anesthesia practice areas. As previously described, access to personal hand gel improved compliance among regional anesthesia teams [65]. Similarly, it was demonstrated that alcohol-based HH was the optimal technique prior to labor epidural placement [66]. Continuous nerve catheters are an increasingly common regional anesthesia technique. As with other techniques, the incidence of infectious complications is rare. Risk factors for complication include critically ill patients, duration of catheter use, and location [67]. Maximal sterile precautions like those used during epidural placement can be recommended during nerve catheter placement [68]. Hand hygiene is a foundational cornerstone to aseptic technique and patient safety during regional and neuraxial anesthesia. However, the risk of developing infection during these procedures remains, leaving opportunities for continued research in infection prevention in these fields.

Description of Search Methods

A bibliographic search of the databases—Embase and MEDLINE/PubMed was performed using a combination of relevant keywords and subject heading terms for perioperative infection control strategies and practices for preventing surgical site infections. The results were further curated by authors based on their year of publication, citation count, randomized control trials versus retrospective studies, and was then used to serve as reference material for this review. Secondary searching included manual searching of relevant reference lists for articles not identified in the primary search and review of citation listings. One of the authors (RL), having participated in a significant body of work in the area of perioperative infection control, reviewed the entire bibliographic library to ensure the validity, accuracy, and alignment with current practices and recommendations. The complete bibliography has been provided at the end of this review as references.

Conclusion

A multimodal, evidence-based anesthesia work area infection control program is indicated for maximal attenuation of pathogen transmission and subsequent infection development. This includes hand hygiene, environmental cleaning, vascular care, and patient decolonization improvement strategies optimized by feedback. A critical implementation feature for intraoperative hand hygiene is provider proximity given the fast-paced, high task density environment. Evidence suggests that anesthesia providers should strive for 8 hourly hand decontamination events according to the WHO 5 moments of hand hygiene. While intraoperative infection control is not as simple as washing one's hands, hand hygiene remains an important component of multimodal, evidence-based strategies that if successfully employed, can generate substantial reductions in SSIs and pathogen transmission events.

Declarations

Conflict of Interest Colby G. Simmons declares no competing interests.
Jacob M. Loyd declares no competing interests.
Andrew W. Hennigan declares no competing interests.
Archit Sharma declares no competing interests.
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Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authoes.

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