



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

# Anesthesia as a Risk for Health Care Acquired Infections

Barbara A. Smith, RN, BSN, MPA, CIC

## KEYWORDS

• Health care infections • Anesthesia • Transmission

Modern health care relies on the provision of safe, effective anesthesia to patients undergoing surgery or other invasive procedures. It is perhaps while patients are receiving anesthesia that they are most vulnerable, as they must depend on the anesthesia team to provide this care without untoward effects. One expectation is that the patient will be protected from health care acquired infections (HAIs) by appropriate use of infection prevention measures. In addition, the anesthesia team may be at risk of HAIs because of their intimate contact with the patient's blood and respiratory system. Similarly, adequate adherence to infection prevention methods should reduce the risk of occupational exposure and infection to the anesthesia team members.

Health care associated infections involving anesthesia have been transmitted from health care worker to patient, patient to patient, and patient to the anesthesia provider. A recent report describes the development of bacterial meningitis in 5 women after intrapartum spinal anesthesia in which the route of transmission was from the anesthesiologist to the patient.<sup>1</sup> There have been several reports of patients acquiring viral hepatitis from other patients because of breaches in administration of parenteral anesthesia agents.<sup>2,3</sup> Occupational infections have occurred both through the contact route,<sup>4</sup> as with herpetic whitlow, and the respiratory route, as during the severe acute respiratory syndrome (SARS) outbreak in Toronto, Canada.<sup>5</sup>

Anesthesia is delivered in a variety of modalities including general, regional, or local anesthesia. The anesthetist's role has increasingly expanded to include the administration of other medications such as for conscious sedation or pain-alleviating drugs. While the anesthesia team has traditionally served in the operating rooms of acute care hospitals, their role has greatly expanded to ambulatory care centers, diagnostic, treatment, and procedure areas, pain management practices, and critical care units. This development has created a challenge for adherence to the highest standard of care for the prevention of infection. Regardless of the health care setting or the level

---

There are no financial disclosures.

Division of Infectious Diseases and Epidemiology, St Luke's Roosevelt Hospital Center, 1111 Amsterdam Avenue, New York, NY 10025, USA

*E-mail address:* [basmith@chpnet.org](mailto:basmith@chpnet.org)

Perioperative Nursing Clinics 5 (2010) 427–441

doi:10.1016/j.cpen.2010.07.005

[periopnursing.theclinics.com](http://periopnursing.theclinics.com)

1556-7931/10/\$ – see front matter © 2010 Elsevier Inc. All rights reserved.

of provider, the standard of care for infection prevention and managerial oversight of this care should remain the same.

The anesthesia team has direct and indirect responsibility for the prevention of infections, which may manifest most commonly as bloodstream infections, local injection site infections, abscesses, meningitis, respiratory tract infections, and surgical site infections (SSIs). Bacterial and viral infections may also be attributed to anesthetic care.

Because anesthesia care interrupts two of the body's significant defense mechanisms, there is the potential for risk of infection to the patient.

First, the body's intact skin functions as a barrier to pathogenic organisms. However, intravascular cannulation for conscious sedation disrupts the skin integrity and permits a local or systemic infection to occur. These risks also apply to central venous vascular catheters inserted by the anesthesiologist, whether in the operating room or as part of a critical care team. Insertion of a needle, cannula, or implantable device into the spinal column for anesthesia or analgesia disrupts the skin integrity and provides a direct portal of entry for organisms.

Second, surgery will often be performed with general anesthesia that involves the insertion of an endotracheal tube to maintain an open airway and permit artificial ventilation during the procedure. Although endotracheal intubation during surgery is generally a controlled safe procedure, this artificial airway predisposes the body to exposure to respiratory pathogens whether from the health care provider, the environment, or equipment. The same risk arises when intubation is performed during an emergency situation such as cardiopulmonary resuscitation. Measures to prevent this exposure, including the role of the environment and equipment, are discussed in this article.

Third, although not physically involved at the sterile operative field, the anesthesia team can have influence over the development of SSIs by their collaboration with the surgical team in achieving normothermia, glycemic control, and appropriate antibiotic prophylaxis for the patient.<sup>6</sup>

Finally, the author examines occupational measures to prevent infections in the health care worker.

### **INFECTIOUS RISKS ASSOCIATED WITH THE INTERRUPTION OF THE SKIN BARRIER VIA DEVICES THAT PENETRATE THE SPINAL COLUMN**

Access to the spinal column is used to provide regional anesthesia, for example with epidural anesthesia, or to deliver medication such as analgesics or steroids. Other examples of procedures that enter the spinal column include diagnostic procedures such as lumbar puncture and myelography.

The overall risk of infection from these procedures appears to be low. Miller<sup>7</sup> cites a rate of less than 1 per 10,000 cases of serious infection (ie, meningitis or spinal abscess). He notes 2 factors that had a relation to infection: the duration of epidural anesthesia and the patient's medical conditions. In a review conducted through 2005, Schulz-Stübner and colleagues<sup>8</sup> noted rates of 3.7 to 7.2 spinal abscesses per 100,000 cases and 0.2 to 83 epidural abscesses per 100,000 procedures. Baer<sup>9</sup> lists 179 cases of postdural meningitis occurring after spinal or epidural anesthesia and other types of instrumentation. Spinal or epidural anesthesia accounted for 65% of the cases (**Table 1**).

Some investigators have argued that the true incidence is unknown because there is no uniform reporting mechanism in the United States. Nonetheless, Ruppen and colleagues<sup>10</sup> attempt to define the risk in obstetric epidural anesthesia and cite a rate of 1 deep epidural infection per 145,000 procedures; an admittedly low

Spinal	96
Epidural	21
Myelography	29
Diagnostic lumbar puncture	17
Combined spinal-epidural	10
Steroid injection	2

Data from Baer E. Post dural puncture meningitis. *Anesthesiology* 2006;105(2):381–93.

incidence. Nonetheless, in an American Society of Anesthesiology newsletter, Hughes<sup>11</sup> urges his obstetric colleagues that they can lower the risk to their patients.

Evidence of infection transmission is also documented in the descriptions of outbreaks. Five women in two separate states (New York and Ohio) developed bacterial meningitis after intrapartum anesthesia (**Table 2**).<sup>1</sup> The article reveals that the causative organism was recovered from a nasal swab of one of the anesthesiologists linked to the 2 cases in Ohio. In each outbreak, unmasked personnel (including the anesthesiologist delivering the spinal anesthesia in Ohio) were present in the room during the procedures.

Eight cases of meningitis following myelography were reported by the Centers for Disease Control and Prevention (CDC) that appear related to contamination from mouth flora from the clinicians who performed the procedure.<sup>12</sup> As part of the investigation, the CDC eliminated equipment and fluids as a potential source for these infections, and confirmed that adequate aseptic technique had been followed.

As described by Baer,<sup>9</sup> the mechanism of infection in these cases occurs through:

- Droplet transmission of aerosolized mouth organisms,
- Contamination from skin bacteria or
- Hematogenous or direct spread from an endogenous site of infection.

Regarding this first method of transmission, the likelihood is that some of these infections are related to the clinician who performed the procedure. This assumption is supported by arguments that several cases were related to clusters among specific operators, or were linked by DNA testing of nasal swabs from the operator and positive cerebrospinal fluid cultures, as in the Ohio case cited.

These data suggest that the clinician can implement preventive practices related to anesthesia or analgesia given through the spinal cord to reduce the likelihood of infection. These practices include skin disinfection with an appropriate antiseptic, sterile

Location	No. of Women	Organism	Outcome
New York	3	<i>Streptococcus salivarius</i> in 2 patients No growth in 1 patient	All recovered
Ohio	2	<i>S salivarius</i> both patients	One recovered One expired

Data from Centers for Disease Control and Prevention. Bacterial meningitis after intrapartum spinal anesthesia—New York and Ohio, 2008–2009. *MMWR Morb Mortal Wkly Rep* 2010;59:65–9.

gloves and sterile drapes, and aseptic technique. Because of the growing evidence for droplet transmission of oropharyngeal flora during the procedures that puncture the spinal column, the CDC's Guidelines for Isolation Precautions recommend the use of a surgical mask by personnel placing a catheter or injecting material into the spinal canal or subdural space.<sup>12</sup> A recent practice advisory prepared by the American Society of Anesthesiologists (ASA) concurs with the implementation of aseptic technique when handling neuraxial needles and catheters, and states it should include "hand washing, wearing of sterile gloves, wearing of caps, wearing of masks covering both the mouth and nose, use of individual packets of skin preparation, and sterile draping of the patient." The same advisory does not make a specific recommendation regarding the type of skin antiseptics to use.<sup>13</sup>

### **INFECTIOUS RISKS ASSOCIATED WITH THE INTERRUPTION OF THE SKIN BARRIER VIA DEVICES THAT ENTER THE INTRAVASCULAR SYSTEM**

Intravascular catheters, including central and peripheral venous catheters and arterial catheters, play an integral part in the delivery of anesthesia or analgesia. Once again, these devices provide an opportunity for organisms to enter the normally sterile vasculature.

The insertion and care of these catheters should remain the same regardless of whether they are inserted in an operating room, a critical care unit or a free-standing practice.

There are 2 key mechanisms by which a catheter can lead to an infection.<sup>14</sup> The first occurs with colonization of the device and is referred to as catheter-associated infection. The pathogenesis of these types of infections is:

- Skin organisms gain entry via the puncture site at time of insertion or shortly thereafter,
- The catheter hub can become contaminated during use or
- Organisms spread hematogenously from another site of infection in the body.

Catheter-associated infections can lead to local site infections or systemic infections including bacteremia, sepsis, or endocarditis.

The second mechanism occurs with contamination of the medication or substance being injected, which is referred to as infusate-associated infection. Although intrinsic contamination of intravenous fluids or medications from the manufacturer is rare in the United States, improper procedures by the anesthetist or technician during medication preparation and administration can lead to infusate-associated infections. In this situation the bacteria, virus, or fungus is directly infused into the patient's bloodstream.

### **CATHETER-ASSOCIATED AND INFUSATE-ASSOCIATED INFECTION**

The rate of catheter-associated infections varies by the type of device used. For peripherally inserted, short-term catheters the risk is low. Lee and colleagues<sup>15</sup> report a local site infection rate of 2.1% to 2.6% among 3165 patients with short peripheral intravenous catheters. No patients in this group developed a bloodstream infection. Rates of arterial line catheter infections are similarly low, with Lucet and colleagues<sup>16</sup> and Koh and colleagues<sup>17</sup> reporting rates of 1.0 and 0.92 bacteremias per 1000 catheter days, respectively. These investigators report low rates of bacteremias related to central venous lines as well. The risk of central line-associated bloodstream infections in critical care patients ranges from 1.3 infections per 1000 catheter days in pediatric medical units to 5.5 in burn units.<sup>18</sup> **Table 3** lists the central line-associated bloodstream infection rates in a sample of units in which the anesthetist may have involvement.

Table 3 Central line-associated bloodstream infection rate per 1000 central venous line days in selected units	
Critical Care Units	
Neurosurgical	2.5
Pediatric cardiothoracic	3.3
Surgical	2.3
Surgical cardiothoracic	1.4
Trauma	3.6
Inpatient Wards	
Labor, delivery, postpartum	0.0
Neurosurgical	0.9
Orthopedic	0.8
Surgical	1.4

Data from Edwards JR, Peterson K, Mu Y, et al. National Healthcare Safety Network report (NHSN): data summary for 2006 through 2008, issued December 2009. *Am J Infect Control* 2009;37:783–805.

Although it is possible for individual solutions to become contaminated and subsequently infused into patients, it is difficult to attribute an individual infection to a specific medication, vial, or infusion bag without direct causal evidence. Hence, data related to infusate-related infections derives mainly from experiences with outbreaks. For example, Blossom and colleagues<sup>19</sup> describe an outbreak of 162 *Serratia marcescens* bacteremias in 9 states related to manufacturer's contamination of prefilled heparin and saline syringes. These circumstances are clearly beyond the control of the anesthesia team, although the team must respond promptly to alerts regarding potential contamination. There are, however, reports of medication contamination occurring under the control of the anesthesia personnel.

In 2003, *Morbidity and Mortality Weekly Report* reported hepatitis B and C virus transmission occurring in 3 separate locations.<sup>3</sup> In each of these practices, reuse of needles and syringes and contamination of multidose medication vials led to patient-to-patient transmission of viral infections. As depicted in **Table 4**, more than 200 people were affected.

Despite this significant number of patient-to-patient transmissions, practitioners have continued to demonstrate unsafe medication practice. As recently as 2008, 6 patients were infected with hepatitis C due to unsafe injection practice used during sedation for endoscopic procedures.<sup>2</sup> The investigation revealed that the anesthesia provider contaminated vials of propofol by repeated aspiration into the vial with a syringe contaminated with hepatitis C from backflow of the index patient's blood. Although the vial was labeled for single-patient use, the practitioner used the vial on the next patients. A graphical example is shown in **Fig. 1**.

## MEASURES TO PREVENT CATHETER-ASSOCIATED AND INFUSATE-ASSOCIATED INFECTIONS

The CDC has published extensive guidelines for the prevention of intravascular infections.<sup>20</sup> Key elements intended to reduce catheter-associated infections that

Location	Practice Setting	Improper Techniques	Patients Infected
New York City	Endoscopy practice	Contamination of MDV of anesthesia medication	12: hepatitis C
New York City	Medical office	Contamination of MDV used for IM injections	29: hepatitis B
Oklahoma	Pain management	Reuse of needle and syringe for sedatives	69: hepatitis C 31: hepatitis B
Nebraska	Hematology-oncology practice	Use of single IV flush bag during infusions to multiple patients	99: hepatitis C

*Abbreviations:* IM, intramuscular; IV, intravenous; MDV, multidose vial.

*Data from* Centers for Disease Control and Prevention. Transmission of hepatitis B and C viruses in outpatient settings: New York, Oklahoma and Nebraska, 2000–2002. *MMWR Morb Mortal Wkly Rep* 2003;52:901–6.

apply to peripheral, central, or arterial catheters handled by the anesthesia team include:

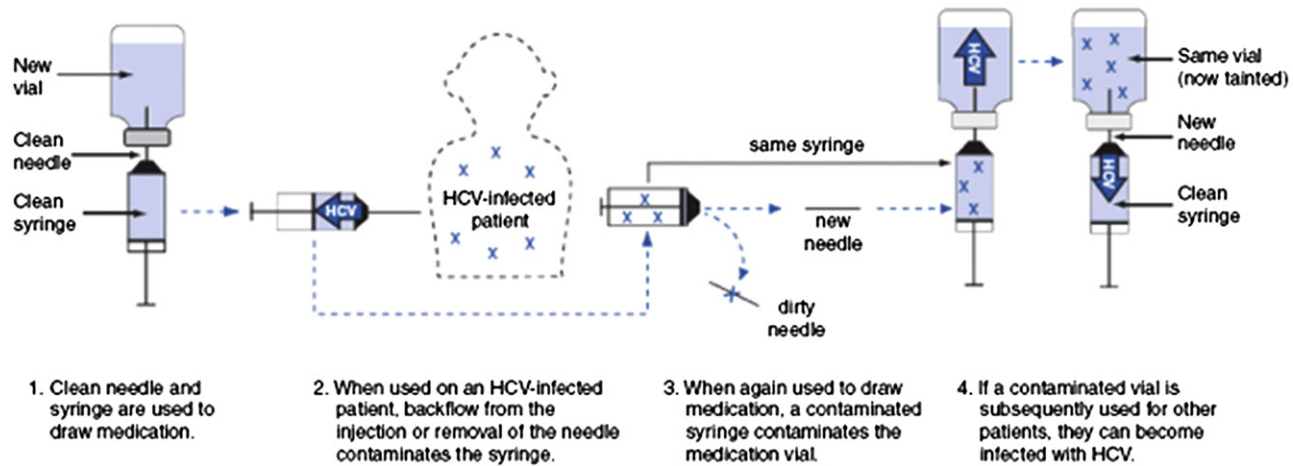
- Skin disinfection of the intravenous insertion site with an appropriate disinfection (a chlorhexidine-based preparation is preferred),
- Aseptic technique during insertion and care and
- Decontamination of ports and stopcocks with a disinfectant such as 70% alcohol before accessing the device.

The CDC guidelines and the ASA recommend additional specifications for the insertion and maintenance of central venous catheters because of their higher risk of infection.<sup>21</sup> Many facilities have adopted a bundle approach to the insertion of central line catheters both in the operating room and elsewhere. The elements of the bundle are:

1. Hand hygiene before insertion
2. Full barrier precautions: sterile gown, gloves, masks, and large sterile drapes
3. Skin antisepsis with chlorhexidine
4. Subclavian vein as preferred anatomic site versus internal jugular or femoral
5. Daily review of line necessity.

From the anesthetist's perspective, the elimination of infusate-related infections demands preventing contamination of medications and infusions. Most practitioners presumably would report adherence to safe medication handling. Yet a survey conducted by the American Association of Nurse Anesthetists (AANA) revealed that 1% to 3% of clinicians reuse needles or syringes on multiple patients.<sup>22</sup> The AANA has joined with the CDC, two state medical societies, the Association for Practitioners in Infection Control, and other advocacy groups in the Safe Injection Practices and Awareness Campaign to further educate health care providers and the public about the importance of these practices. The campaign poster is displayed in **Fig. 2**.<sup>23</sup>

Because of the aforementioned outbreaks of hepatitis transmission, the CDC's 2007 Guidelines for Isolation Precautions<sup>12</sup> highlights safe injection practices that



**Fig. 1.** Unsafe injection practices and circumstances that likely resulted in transmission of hepatitis C (HCV) at clinic A, Nevada 2007. (From Centers for Disease Control and Prevention. Acute hepatitis C virus infections attributed to unsafe injection practices at an endoscopic clinic—Nevada 2007. MMWR Morb Mortal Wkly Rep 2008;57:513–7.)





**Fig. 2.** Poster for safe injection practices. (Courtesy of S. Weir, Safe Injection Practices Coalition—One and Only Campaign; with permission.)

are outlined in **Fig. 3**. The ASA supports these practices<sup>21</sup> and makes further recommendations:

- Cleanse rubber septum of vials and the neck of glass ampoules with a disinfectant.
- Medications should be drawn up as close as possible to the time of use.
- Medications in a syringe should be discarded within 24 hours unless specified by the manufacturer or pharmacy.
- Expiration times for medications must be followed, especially the time limits for the use of lipid formulations such as propofol.

- Never administer medications from the same syringe to more than one patient, even if the needle is changed.
- Consider a syringe or needle contaminated after it has been used to enter or connect to a patient's intravenous infusion bag or administration set.
- Do not enter a vial with a used syringe or needle.
- Never use medications packaged as single-use vials for more than one patient.
- Assign medications packaged as multi-use vials to a single patient whenever possible.
- Do not use bags or bottles of intravenous solution as a common source of supply for more than one patient.
- Follow proper infection-control practices during the preparation and administration of injected medications.

**Fig. 3.** Injection safety recommendations. (Adapted from the Centers of Disease Control. Guideline for isolation precautions: preventing transmission of infectious agents in health-care setting 2007. Atlanta (GA): US Department of Health and Human Services, CDC; 2007. Available at: [http://www.cdc.gov/ncidod/dhqp/gl\\_isolation.html](http://www.cdc.gov/ncidod/dhqp/gl_isolation.html).)

## RISKS OF INFECTION RELATED TO INTUBATION, MECHANICAL VENTILATION, AND ANESTHESIA EQUIPMENT

According to the National Health Care Safety Network, the range of postprocedure pneumonias varies greatly by procedure.<sup>18</sup> For example, among those procedures reporting more than 1000 cases, patients undergoing knee prosthesis had a rate of 0.06 postoperative pneumonias per 100 procedures compared with cardiac surgery patients who had a rate of 1.19 pneumonias per 100 procedures. Some additional information is gleaned from examining rates of ventilator-associated pneumonias (VAP). Among surgical type critical care units, the pooled mean rate per 1000 ventilator days was a low of 0.6 in pediatric cardiothoracic units to a high of 8.1 in trauma units. However, it is difficult to distinguish how much of a direct impact intubation and anesthesia had on the development of these pneumonias. One study by Rello and colleagues<sup>24</sup> examined the development of pneumonia within the first 48 hours of intubation. Eighteen of 250 intensive care unit (ICU) patients developed pneumonia within the first 24 hours. There were 65 surgical patients included in this study. The 2 most important risk factors for pneumonia in patients were undergoing cardiopulmonary resuscitation and receiving conscious sedation. The investigators conclude that variables directly related to the intubation had less of an impact on the occurrence of pneumonia.

Nonetheless, intubation places the patient at risk of infection for several reasons. Because intubation interrupts the defense mechanisms of the upper airway, it increases the risk of aspiration. Aspiration of oral pharyngeal secretions is a prime cause of health care acquired pneumonia. This condition may be further aggravated by mechanical damage to the larynx or trachea from the endotracheal tube or stylet.<sup>7</sup> Furthermore, mechanical ventilation increases the risk of infection.

Measures to reduce infection risk associated with intubation and mechanical ventilation deal with technique and equipment. Cheung and colleagues<sup>25</sup> reviewed the literature to determine the impact of sterile handling of the endotracheal tube and the incidence of pneumonia. Of note, the investigators found very few data on the topic yet noted that intubations performed under unsterile conditions do occur, although they do not provide a recommendation. It is prudent for intubation to be performed as aseptically as possible, with personal protective equipment worn for the safety of the health care worker.

Oral intubation is preferred over nasal intubation because the latter is more likely to lead to sinusitis, thereby increasing the risk of aspiration of infected secretions.<sup>26</sup> Care should be taken to drain condensate in the ventilator tubing away from the patient. Although there are other measures to reduce VAP such as mouth care and semirecumbent position of the patient, these apply after the intraoperative period.

Equipment utilized by the anesthesia team includes endotracheal tubes, laryngoscope handles and blades, fiberoptic endoscopes, and anesthesia circuits, machines, and carts. There are also ancillary devices used by the team such as pulse oximetry, invasive temperature probes, and airways. This equipment may become contaminated from contact with the patient's skin, blood, secretions, splashes from the operative field, or contact with contaminated hands of the health care worker. The CDC, ASA, and AANA each have comparable standards for cleaning and disinfection of these items. These standards are based on the Spaulding classification method<sup>27</sup> that stratifies items based on their likely contact with a sterile body site, mucus membrane, or intact skin, as noted in **Table 5**.

Neither the CDC<sup>12</sup> nor the ASA<sup>21</sup> recommends the routine use of a bacterial filter for the breathing circuits or anesthesia ventilators. Conversely, the AANA states "protective

<b>Risk</b>	<b>Definition</b>	<b>Reprocessing Method</b>	<b>Examples</b>
Critical items	Enter a sterile area of the body or vascular system	Require sterilization	Vascular needles Needles and catheters used for regional blocks
Semicritical items	Contact mucous membranes but do not penetrate them	High-level disinfection	Laryngoscope blades Esophageal catheters Stylets
Noncritical items	Touch intact skin or do not make contact with the patient	Intermediate- to low-level disinfection	Electrocardiogram cables Exterior of the anesthesia machine

From Centers for Disease Control and Prevention. Guideline for disinfection and sterilization in healthcare facilities, 2008. Available at: [http://www.cdc.gov/hicpac/pdf/guidelines/Disinfection\\_Nov\\_2008.pdf](http://www.cdc.gov/hicpac/pdf/guidelines/Disinfection_Nov_2008.pdf).

use of bacterial filters is recommended,” although they do acknowledge its use is controversial.<sup>28</sup> Each of these organizations supports the use of a bacterial filter when caring for an infectious tuberculosis patient. Another debated topic is the disinfection of laryngoscope handles. Because they do not enter sterile tissue or touch mucous membranes, the Spaulding classification would indicate cleaning and low-level disinfection. There is, however, the risk of contamination with body fluids. Call and colleagues<sup>29</sup> challenged a common practice of wiping blades with low-level disinfectant between operative cases. After culturing 40 handles that had been cleaned according to the facilities’ standard practice, they found 75% had positive bacterial cultures.

Most importantly, standard protocols should be developed that outline the correct cleaning, disinfection, or sterilization process for each item used by the anesthesia team. The manufacturer of the equipment should be consulted for their recommendations. An oversight mechanism should be included in the policy to ensure adherence with the correct practice. Adequate training must be provided.

Overall, the documented transmission of infection from anesthesia equipment appears to be low. Yet Loftus and colleagues<sup>30</sup> raise the issue of transmission of bacteria in the anesthesia work area. These investigators cultured 2 specific areas of the anesthesia machine and the sterile stopcock just before the beginning of the case and again at the end of the case. Their results showed that 32% of the stopcocks were contaminated by the end of the case. The work area showed a significant increase in bacterial contamination as well. Two cases of methicillin-resistant *Staphylococcus aureus* (MRSA) were transmitted to the work area intraoperatively. One case of vancomycin-resistant *Enterococcus* transmission was documented between the anesthesia work area and the stopcock. The investigators also noted a trend toward increased HAIs among patients with contaminated stopcocks. The machine and stopcocks appear to have become contaminated by contact with providers’ hands or lapses in aseptic technique.

These results reinforce the need for rigorous attention to hand hygiene not only before the start of surgery but also intraoperatively. Most studies indicate that adherence to hand hygiene by health care workers needs to be improved. McGuckin and colleagues<sup>31</sup> report only modest improvement to 51% compliance among non-ICU staff after a year-long program of observation and feedback. A 2004 report by Pittet and colleagues<sup>32</sup> found a 23% compliance rate among anesthesiologists. Hand hygiene is clearly a challenge in the operating room because of the multiple functions being performed. Limited access to hand hygiene products within the operating room undoubtedly contributes to poor compliance in the room.

Koff and colleagues<sup>33</sup> address this latter challenge through a study utilizing a portable device that dispenses alcohol-based hand rub. The device has the added benefit of tracking the frequency of use and providing a reminder if too long a time has elapsed between hand hygiene events. The introduction of the device was considered the study phase. During the study phase, hand hygiene events increased among attending anesthesiologists and other caregivers by 6.9 and 8.3 times per hour, respectively. The investigators also monitored the frequency of stopcock contamination and the occurrence of HAIs, and demonstrated decreases in both of these indicators as noted in **Table 6**. While the reduction in HAIs is promising, Koff and colleagues caution that additional research is needed to confirm these results.

#### ADDITIONAL ROLES FOR THE ANESTHESIA TEAM IN PREVENTION OF SURGICAL SITE INFECTIONS

SSIs are the second most frequent HAI.<sup>34</sup> Control measures for the prevention of SSIs include preoperative preparation of the patient, sterile attire and draping, surgical hand preparation, skin antisepsis, air handling, and sterile surgical instrumentation. There are additional conditions that can influence the occurrence of SSIs when the anesthesiologist may be involved.

One measure aimed at reducing bacteria at the surgical site is the delivery of antibiotic prophylaxis. The National Surgical Infection Prevention Project (SIP) proposes a 25% reduction in national surgical complication rates by adherence to 3 indicators<sup>35</sup>:

1. Administration of an appropriate antibiotic as described by the SIP. The antibiotic is selected based on the organisms most likely to cause infection and varies by the type of surgery.

	Control Group	Study Group
Number of procedures	58	53
Stopcock contamination	32.8%	7.5%
HAIs	17.2%	3.8%
Types of HAIs	2 VAPs 5 wound 2 bloodstream 1 UTI	2 wound

*Abbreviations:* UTI, urinary tract infection; VAP, ventilator-associated pneumonia.

*Data from* Koff M, Loftus R, Burchman C, et al. Reduction in intraoperative bacterial contamination of peripheral intravenous tubing through the use of a novel device. *Anesthesiology* 2009; 110:978–85.

2. Timely administration of the antibiotic. To reach adequate blood and tissue concentrations, the antibiotic should be administered within the 60 minutes prior to the surgical incision. (Vancomycin may be given up to 120 minutes prior.)
3. Discontinuation of prophylactic antibiotics with 24 hours (48 hours for cardiac surgery).

A second intervention to reduce SSIs is the maintenance of normothermia. Hypothermia is thought to contribute to infection because of a decrease in subcutaneous tissue perfusion.<sup>6</sup> Lastly, glycemic control has been shown to reduce the rate of infections.

## PREVENTION OF INFECTIONS IN ANESTHESIA PERSONNEL

Anesthesia providers are at risk of occupational infections from direct contact with blood and respiratory secretions. In addition, they may be exposed to microorganisms via the airborne or droplet route.

Diseases transmitted through the airborne route include tuberculosis, measles, and varicella. Most clinicians should be immune to measles and varicella because of effective vaccines. Surgery should be delayed for patients with these active infections. If the case cannot be postponed, the air handling in the operating room should ideally have negative pressure relative to the corridor. As previously mentioned, a bacterial filter should be placed on the anesthesia breathing circuit for patients with active tuberculosis. The health care provider should wear an N95 respirator approved by the National Institute for Occupational Safety and Health. When called to intubate patients on airborne isolation, again the N95 respirator is indicated. A large number of SARS cases in Canada were occupationally acquired. Fowler and colleagues<sup>5</sup> determined in one small series that physicians and nurses involved in intubation had a relative risk of 3.82 and 13.29, respectively, of developing SARS. This result stresses adequate respiratory protection.

Infections spread through the droplet route include pertussis, mumps, and influenza. As most of these cases are unlikely to undergo elective surgery or procedures while symptomatic, the exposure may occur from undiagnosed cases or from people who are shedding organisms in the few days prior to symptoms. Respiratory protection is indicated for known or suspect cases. Immunization is strongly encouraged. (For the 2009–2010 influenza season, the CDC recommended use of an N95 for contact with patients with influenza-like symptoms. Current recommendations can be found at <http://www.cdc.gov/flu/professionals>.) Hand hygiene is indicated.

Because of their contact with blood and other body fluids, anesthesia providers may be exposed to viral pathogens such as hepatitis B or C and human immunodeficiency virus (HIV). It is difficult to determine the actual number of occupationally acquired blood-borne infections in the discipline. In a 1998 study among anesthesia personnel, the estimated average 30-year risks of HIV or hepatitis C virus infection per full-time equivalent was 0.049% and 0.45%, respectively.<sup>36</sup>

In addition, there may be exposure to bacterial pathogens such as MRSA and *Clostridium difficile*. The AANA supports the CDC's recommendations to use standard precautions in the care of all patients.<sup>28</sup> In summary, standard precautions entail:

- Consider all blood and body fluid as potentially infectious.
- Use of personal protective equipment (PPE) (gloves, gowns, protective eye wear, and masks) when anticipating contact with blood or body. The PPE worn will depend on the task being performed and the possibility that splash or aerosolization can occur.
- Handle and dispose of all needles and syringes properly.

The practitioner should be aware of his or her facility's protocol for managing occupational exposure to blood and body fluid. Body fluid exposures should be evaluated promptly to determine the need for antiviral or other prophylaxis.

Transmission-based precautions may be added for particular diseases that are highly transmissible or of epidemiologic importance. There are 3 categories: airborne isolation, droplet precautions, and contact precautions.

## SUMMARY

The documented risk of infection related to anesthesia is low, yet the potential exists for serious infectious outcomes including death. The risk of infection can be minimized by adherence to hand hygiene, aseptic technique, safe infection practices, equipment decontamination, and use of PPE by all members of the anesthesia team.

## REFERENCES

1. Centers for Disease Control and Prevention. Bacterial meningitis after intrapartum spinal anesthesia—New York and Ohio, 2008–2009. *MMWR Morb Mortal Wkly Rep* 2010;59(3):65–9.
2. Centers for Disease Control and Prevention. Acute hepatitis C virus infections attributed to unsafe injection practices at an endoscopic clinic—Nevada 2007. *MMWR Morb Mortal Wkly Rep* 2008;57(19):513–7.
3. Centers for Disease Control and Prevention. Transmission of hepatitis B and C viruses in outpatient settings: New York, Oklahoma and Nebraska, 2000–2002. *MMWR Morb Mortal Wkly Rep* 2003;52(38):901–6.
4. Barash P, Cullen B, Stoelting R. *Clinical anesthesia*. Philadelphia: Lippincott, Williams and Wilkins; 2006. p. 85.
5. Fowler R, Guest C, Lapinsky S. Treatment of severe acute respiratory syndrome during intubation and mechanical ventilation. *Am J Respir Crit Care Med* 2004; 169(11):1198–202.
6. Mauermann W, Nemergut E. The anesthesiologist's role in the prevention of surgical site infection. *Anesthesiology* 2006;105(2):413–21.
7. In: Miller RD, editor. *Anesthesia*. 6th edition. Philadelphia: Elsevier/Churchill Livingstone; 2005. p. 2742–3.
8. Schulz-Stübner S, Pottinger JM, Coffin SA, et al. Nosocomial infections and infection control in regional anesthesia. *Acta Anaesthesiol Scand* 2008;52(8):1144–57.
9. Baer E. Post dural puncture meningitis. *Anesthesiology* 2006;105(2):381–93.
10. Ruppen W, McQuay H, Moore R. Incidence of epidural hematoma, infection and neurologic injury in obstetric patients with epidural analgesia/anesthesia. *Anesthesiology* 2006;105(20):394–9.
11. Hughes S. Neuraxial blockade in obstetrics and complications related to infection: can we lower the risk? Park Ridge (IL): American Society of Anesthesiology newsletter. February, 2007;vol. 71. Available at: [http://www.asahq.org/newsletters/2007/02-07/hugehs02\\_07.html](http://www.asahq.org/newsletters/2007/02-07/hugehs02_07.html). Accessed February 7, 2010.
12. Siegel J, Rhinehart E, Jackson M, et al, Centers for Disease Control and Prevention. Guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings. 2007. Available at: <http://www.cdc.gov/hicpac/2007IP/2007isolationPrecautions.html>. Accessed January 20, 2010.
13. Horlocker T, Birnbach D, Connis R. Practice Advisory for the prevention, diagnosis, and management of infectious complications associated with neuraxial techniques: a report by the American Society of Anesthesiologists task force

- on infectious complications associated with neuraxial techniques. *Anesthesiology* 2010;112(3):530–45.
14. Crnich C, Maki D. Intravascular device infection. In: Carrico R, editor. *APIC text of infection control and epidemiology*. 3rd edition. Washington, DC: APIC; 2009. p. 24:1–24:22.
  15. Lee WC, Chen HL, Tsai T, et al. Risk factors for peripheral intravenous catheter infection in hospitalized patients: a prospective study of 3165 patients. *Am J Infect Control* 2009;37(8):683–6.
  16. Lucet JC, Boudama L, Zahar JR. Infectious risk associated with arterial catheters compared to central venous catheters. *Crit Care Med* 2010;38:1030–5. Accessed February 26, 2010.
  17. Koh DB, Gowardman JR, Rickard CM, et al. Prospective study of peripheral arterial catheter infection and comparison with concurrently sited central venous catheters. *Crit Care Med* 2008;36(2):397–402.
  18. Edwards JR, Peterson K, Mu Y, et al. National healthcare safety network report (NHSN): data summary for 2006 through 2008, issued December 2009. *Am J Infect Control* 2009;37:783–805.
  19. Blossom D, Nobel-Wang J, Su J. Multistate outbreak of *Serratia marcescens* bloodstream infections caused by contamination of prefilled heparin and isotonic sodium chloride solution syringes. *Intern Med* 2009;169(18):1705–11.
  20. Centers for Disease Control and Prevention. Guidelines for prevention of intravascular catheter-related infections. *MMWR Morb Mortal Wkly Rep* 2002;51(RR10):1–26.
  21. American Society of Anesthesiologists. Recommendations for infection control for the practice of anesthesiology. 2nd edition. Park Ridge (IL): ASA Publications; 1999.
  22. American Association of Nurse Anesthetists. AANA condemns unsafe injection practice. Press release. March 6, 2008. Available at: <http://www.aana.com/news.aspx?id=12396&terms=safe+injection>. Accessed February 14, 2010.
  23. One and Only Campaign. Available at: <http://67.228.183.132/%7Ehardtime/OneandOnly/index.html>. Accessed February 24, 2010.
  24. Rello J, Diaz E, Roque M, et al. Risk factors for developing pneumonia within 48 hours of intubation. *Am J Respir Crit Care Med* 1999;159(6):1742–6.
  25. Cheung N, Betro G, Luckianow G, et al. Endotracheal intubation: the role of sterility. *Surg Infect (Larchmt)* 2007;8(5):545–52.
  26. Peyrani P. Pneumonia. In: Carrico R, editor. *APIC text of infection control and epidemiology*. 3rd edition. Washington, DC: APIC; 2009. p. 24:1–24:22.
  27. Rutala W, Weber D, and the HICPAC, Centers for Disease Control and Prevention. Guideline for disinfection and sterilization in healthcare facilities, 2008. Available at: [http://www.cdc.gov/hicpac/pdf/guidelines/Disinfection\\_Nov\\_2008.pdf](http://www.cdc.gov/hicpac/pdf/guidelines/Disinfection_Nov_2008.pdf). Accessed February 7, 2010.
  28. American Association of Nurse Anesthetists. AANA Infection control guide for certified nurse anesthetists. Park Ridge (IL): AANA; 1997.
  29. Call T, Auerbach F, Riddell S. Nosocomial contamination of laryngoscope handles: challenging current guidelines. *Anesth Analg* 2009;109(2):479–83.
  30. Loftus R, Koff M, Burchman C, et al. transmission of pathogenic bacterial organisms in the anesthesia work area. *Anesthesiology* 2008;109:399–407.
  31. McGuckin M, Waterman R, Govednik J. Hand hygiene compliance rates in the United States—a one year multicenter collaboration using product/volume usage measurement and feedback. *Am J Med Qual* 2009;24(3):205–13.

32. Pittet D, Simon A, Hugonnet S, et al. Hand hygiene among physicians: performance, beliefs and perceptions. *Ann Intern Med* 2004;141(1):1–8.
33. Koff M, Loftus R, Burchman C, et al. Reduction in intraoperative bacterial contamination of peripheral intravenous tubing through the use of a novel device. *Anesthesiology* 2009;110(5):978–85.
34. Fry D, Howard R. Surgical site infections. In: Carrico R, editor. *APIC Text of infection control and epidemiology*. 3rd edition. Washington, DC: APIC; 2009. p. 23:1–23:11.
35. QualityNet. Available at: <http://www.qualitynet.org/dcs/ContentServer?c=MQParents&pagename=Medqic%2FContent%2FParentShellTemplate&cid=1228694349383&parentName=Category>. Accessed March 1, 2010.
36. Greene E, Berry A, Jagger J, et al. Multicenter study of contaminated percutaneous injuries in anesthesia personnel. *Anesthesiology* 1998;89(6):1362.