



Infection Control Guide for Certified Registered Nurse Anesthetists

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Introduction

The American Association of Nurse Anesthetists (AANA) has a long history of supporting the infection prevention and control clinical practices of its members, and as such, has a zero-tolerance for practitioner noncompliance with accepted infection prevention and control best practices. The Infection Control Guide for Certified Registered Nurse Anesthetists (CRNAs) is designed to provide current evidence-based information on infection control and prevention topics related to nurse anesthesia care delivery, including but not limited to healthcare-associated infections.

Healthcare associated infections (HAIs) are a national problem engendering a growing sense of risk to the public and urgency in its prevention. HAI is one of the top safety problems patients experience when they enter a healthcare institution. In 2001, there were approximately 1.75 million infections and tens of thousands of deaths from HAI in the United States.¹ Each year more than 5 million U.S. patients undergo insertion of a central venous catheter (CVC), and 250,000 will develop an infection related to the catheter with an associated mortality rate between 12 percent and 25 percent.² Hospitals in the United States incur a total direct cost associated with HAIs ranging from \$28 billion to \$45 billion annually.³ The largest hepatitis C outbreak in U.S. history was in 2008, affecting more than 40,000 people and costing the community between \$16 million and \$22 million dollars.⁴ Despite multiple attempts to educate and motivate healthcare workers to practice infection control, HAIs continue to present a serious and growing problem. There are several types of HAI that are receiving increased attention due to associated widespread incidence, high patient morbidity and mortality, and increased healthcare costs. These include methicillin-resistant *Staphylococcus aureus*, *Clostridium difficile* infection, catheter-associated urinary tract infection, central line-associated blood stream infection (CLABSI), ventilator-associated pneumonia, and surgical site infection (SSI).⁵ Each of these are relevant to nurse anesthesia practice, and several will be discussed in greater detail in this guide. Growing patient morbidity and mortality from these and other HAIs has motivated the involvement of regulatory agencies, the development of numerous HAI prevention measures, and a search for improved infection control.

CRNAs work in environments considered high-risk for exposure to pathogens via multiple routes. By focusing on evidence-based research and best practices, this guide recommends precautionary methods for prevention of patient exposure to microbes and prevention of occupational exposure of CRNAs to environmental pathogens. As an imperative to improve patient and personal safety, CRNAs must make infection prevention and control a primary focus in anesthesia care.

An increasing number of outbreaks of infection in healthcare settings have been reported on a national stage.⁵ Several factors contributing to this trend include the evolution of multiple-drug resistant organisms in response to misuse of antibiotic therapy, mixing of national and international populations, and rapid mutation of bacteria.⁶

Indigenous to the healthcare setting, a major cause of infection is the lack of compliance by healthcare workers with basic prevention techniques such as hand hygiene.^{7,8} In the perioperative setting, failure to follow the principles of asepsis, as well as ineffective equipment cleaning, disinfection, sterilization and surgical site preparation, have all contributed to unacceptably high rates of SSI.⁹ The economic impact of perioperative infection is enormous and costs the U.S. healthcare system millions of dollars annually. Increasingly, third-party payors such as the Centers for Medicare & Medicaid Services (CMS) refuse to reimburse providers for cases in which patients acquire infections due to their healthcare delivery.¹⁰

Infection control expertise has expanded in recent years in response to increased scrutiny of perioperative infections. The science underlying infection control is becoming more sophisticated and advanced. As a consequence, approaches to effective prevention of infection are being acknowledged as essential components of patient care. Multiple entities, such as The Joint Commission, Food and Drug

Administration (FDA), and Centers for Disease Control and Prevention (CDC), are engaged in protecting the public's welfare as it concerns infection prevention.

Failure to follow recommended aseptic practices during injections has contributed to the problem of bloodborne pathogen exposure and infectious disease transmission during anesthesia care. In 2008, the re-use of contaminated syringes and needles led to six documented cases of hepatitis C.¹¹ In response to that event, the AANA proactively engaged CRNAs to prevent future outbreaks due to a lack of provider adherence to infection prevention practices.

This guide offers procedural recommendations based on the latest evidence. These recommendations constitute minimum expected behavioral guidelines. In life-threatening emergencies requiring immediate action, CRNAs should weigh the relative risk to patient life and determine the most appropriate infection control practice. Following emergency care, the clinician should review all actions taken and intervene as appropriate to assure that all infection control guidelines are effectively enacted as soon as possible.

The deleterious effects of HAIs may not be immediately obvious; however, the potential for patient harm is grave. CRNAs have a duty to protect patients and prevent harm, and infection control is an integral part of the care that anesthesia patients expect and deserve.

Preventive Measures: Personal

The following section addresses key infection prevention and control behaviors that CRNAs should employ to minimize the spread of infectious agents. These key areas include hand hygiene compliance, transmission based precautions, safe injection practices, and other aspects of prevention.

Hand Hygiene

The prevention of nosocomial infection is multifaceted and hand hygiene is a crucial component of the equation.^{8, 12, 13} Anesthesia professionals' hands contaminated with bacterial pathogens play an important role in the transmission of contagious diseases to the intraoperative environment and patients.^{7, 14} The evidence shows that hand hygiene reduces transmission of healthcare-associated pathogens.^{8, 15}

Transient flora (e.g., short-lived contaminants easily removed from the skin) are most frequently associated with HAIs. These organisms colonize the superficial layers of the skin and are more amenable to removal by routine hand washing. Healthcare workers acquire transient flora during patient contact or contact with contaminated environmental surfaces within the patient environment.

Resident flora pose a stronger removal challenge due to being attached to deeper skin layers. Persons at high risk of having areas of intact skin colonized with pathogenic flora such as *S aureus* include those with diabetes, chronic renal failure, and chronic dermatitis.⁸

Healthcare practitioners can contaminate their hands with pathogens (*Klebsiella*, vancomycin resistant enterococci, *S aureus*, *C difficile*, gram negative bacteria) by performing "clean" patient care activities (lifting patients) or touching intact areas of a patient's skin (taking a pulse, touching a shoulder).^{8, 16-18} Potential pathogens can be transmitted from the clinician's hands to the patient and the immediate anesthesia environment during routine administration of anesthesia.^{7, 14} Wearing nonsterile gloves during routine patient care reduces the acquisition of pathogens on healthcare workers' hands and wrists, but gloving does not completely prevent contamination. Hand washing is necessary before and after sterile and nonsterile glove removal because of the potential for contamination from glove leaks or contamination during glove removal.^{17, 19}

Various trials have studied the effects of hand washing with different antimicrobial substances, including plain soap and water, chlorhexidine, hexachlorophene, iodine, chloroxylenol, quaternary ammonium compounds, triclosan, and alcohols.^{8, 15, 20}

Soaps are detergent-based products that have minimal, if any, antimicrobial activity. However, thorough hand washing with plain soap can remove dirt, blood and body fluids, and loosely adherent transient flora.¹⁵ When hands are visibly dirty or soiled (blood, body fluids, excretions), hand washing for at least 15 seconds with either plain soap or an antimicrobial soap is effective in removing hand-surface soiling. A disposable towel should be used to turn off the faucet.⁸ Soap and water hand washing should be used when caring for a patient with known or suspected infectious diarrhea (e.g., *C difficile*, norovirus).¹⁵

Alcohol-based hand rubs have activity against a broad spectrum of epidemiologically important pathogens. The effective antimicrobial action of alcohol solutions is due to their ability to denature proteins. Waterless, alcohol-based formulations for hand antisepsis are rapidly germicidal, effectively reduce bacterial counts on hands, and can aid in preventing the transfer of healthcare-associated pathogens.^{7, 8, 21, 22}

In the United States, alcohol-based rubs designed for reducing the number of viable microorganisms on the hands usually contain 60 percent to 95 percent ethanol or isopropanol. In most studies, alcohol-based products are equally or more effective than antimicrobial soaps and antimicrobial detergents (povidone-

iodine, 4 percent chlorhexidine, or triclosan) in reducing the number of pathogens recovered from healthcare workers' hands.^{21, 23-25}

Alcohol-based hand rub preparations are not suitable for use when hands are contaminated with proteinaceous materials (e.g., blood) or are visibly dirty. Further, unlike 4 percent chlorhexidine solutions, alcohol preparations do not result in persistent or residual antimicrobial action before use.

Frequent use of alcohol-based formulations for hand antisepsis can cause drying of the skin, but the drying effect can be reduced or eliminated by adding 1 percent to 3 percent glycerol or other skin-conditioning agents. In fact, alcohol-based preparations containing emollients may cause less skin irritation and dryness than soaps or antimicrobial detergents.

Alcohol-impregnated wipes (towelettes) are not as effective as alcohol-based hand rubs or antimicrobial soaps in reducing bacterial counts on the hands of healthcare workers.²⁶

Chlorhexidine is incorporated into a number of hand-hygiene products. Its rapid and broad spectrum antimicrobial properties are due to disruption of microbial cytoplasmic membranes. The addition of chlorhexidine to alcohol-based preparations results in more persistent antimicrobial activity than alcohol alone.⁸ Chlorhexidine is a cationic compound and its activity has been shown to be reduced by hand lotions containing anionic emulsifying agents and natural soaps.²⁷

The CDC's Healthcare Infection Control Practices Advisory Committee published guidelines on how and when hand hygiene should be performed.^{8, 15} Despite publication of hand hygiene guidelines and the nurse anesthetist's knowledge of germ theory, there is a gap between what is recommended and what is practiced.⁸ Hand hygiene compliance remains a neglected component of safe patient care.²⁸⁻³⁰ This is especially true with anesthesia professionals and physicians, who generally have inconsistent adherence to hand hygiene guidelines.^{7, 29, 31} In the anesthesia setting, which requires the expeditious performance of multiple and complex tasks and procedures, hand hygiene is unacceptably low.

Bacterial contamination of the anesthesia professional's hands before patient care is a modifiable risk factor for cross-contamination between patients and the anesthesia environment.^{7, 14} A 2009 study by Koff, et al provided evidence that frequent intraoperative hand hygiene decontamination with an alcohol-based hand rub solution reduces contamination of the anesthesia work area including intravenous catheter stopcock contamination.⁷ The study also demonstrated that anesthesia professionals are involved in intraoperative bacterial transmission to patients and that frequent hand hygiene reduces microbial transmission and provider transmitted infections.^{7, 14}

Key Recommendations for Hand Hygiene¹⁵

- Hand hygiene should occur before entering the patient operating room or other care areas.^{8, 14}
- Hands should be washed or disinfected before and after having contact with patients or the patient's immediate environment.^{8, 15, 32}
- Hands should be washed with soap and water when caring for a patient with known or suspected infectious diarrhea (e.g., *C difficile*, norovirus).
- Wash hands with soap and water when exposure to spores is expected.
- Wash hands in accordance with hand washing protocol before eating and after restroom use with soap and water.
- All forms of plain, nonantimicrobial soap are acceptable for routine hand washing.
- Wet hands first with water when washing hands, and rub hands together with product for at least 15 seconds. Hot water may increase the risk of dermatitis.

- When hands are visibly dirty or contaminated with body fluids, wash hands with either a nonantimicrobial soap and water or an antimicrobial soap and water.
- When hands are not visibly soiled, an alcohol-based hand rub effectively decontaminates hands.^{8, 15, 32}
- Single-use towels are preferable for drying hands after handwashing.
- Decontaminate hands before wearing sterile gloves when inserting a central intravascular catheter.
- Decontaminate hands before inserting invasive devices.
- Decontaminate hands after contact with body fluids or excretions, nonintact skin, and wound dressings.
- Decontaminate hands if moving from a contaminated to a clean body site while treating patients.
- Decontaminate hands after contact with inanimate objects in the patient environment.
- Antimicrobial wipes may be used when nonantimicrobial soap and water are inaccessible, however, they are not as effective as alcohol-based hand rubs or antimicrobial soaps.
- There is not sufficient evidence to support the routine use of nonalcohol-based hand rubs for hand hygiene.
- When applying an alcohol-based hand rub, place product on the palm of one hand and rub hands until dry.
- Use either an antimicrobial soap or an alcohol-based hand rub before wearing sterile gloves when performing surgical procedures.
- When performing surgical hand antisepsis using an antimicrobial soap, follow manufacturer guidelines for scrub time, usually two to six minutes.
- When using an alcohol-based surgical hand-scrub, follow manufacturer guidelines. Do not wear sterile gloves until hands and forearms are completely dry.
- Wear gloves when contact with blood or other potentially infectious materials, and non-intact skin, could occur.
- Remove gloves and decontaminate hands after caring for a patient. Do not use gloves for more than one patient.
- Change gloves during patient care if moving from a contaminated body site to a clean body site.

Fingernails, Artificial Nails, and Jewelry

The subungual area of the fingers harbor high concentrations of bacteria both before and after handwashing.⁸ The number of bacterial and fungal microorganisms increases with increasing nail length.³³ A two-year prospective, controlled, cross-over trial of intensive care unit (ICU) nurses revealed that higher levels of bacteria were associated with natural fingernails longer than 2 mm.²²

Healthcare workers who wear artificial nails are also at an increased risk of harboring pathogens on their fingertips.^{34, 35} Increased microbial counts are present on artificial nails both before and after handwashing, compared to those who have natural nails.^{8, 33} Artificial nails as well as long, natural nails have been linked to poorer hand washing practices and more tears or microperforations in gloves.^{33, 35} The evidence, however, does not clearly show a direct link between long or artificial fingernails and HAIs.³⁶ The CDC Guidelines for Hand Hygiene in Healthcare Settings strongly advises that practitioners not wear artificial nails or nail extenders when they care for high-risk patients, such as surgical patients.⁸

Finger rings contaminate hands with pathogens. Wearing at least one ring on the dominant hand increases the number of microbes contaminating the hand, including contamination with gram-negative bacilli.²² Even after handwashing, there are higher microbial counts on the hands of healthcare workers who wear rings compared to those who do not wear rings.³⁷

Key Recommendations for Fingernails, Artificial Nails, and Jewelry

- Keep natural nail length to less than approximately ¼ inch.^{8, 32}
- Anesthesia professionals should not wear artificial nails or nail extenders.⁸
- Use a nail cleaner to clean underneath fingernails.
- Remove jewelry prior to the start of performing surgical hand-scrub procedures requiring aseptic techniques.

Prevention and Treatment of Occupational Exposure and Prophylaxis Basic Measures

Nurse anesthetists must observe universal precautions during all patient care to prevent occupational exposure.^{8, 38} These include the following measures: handwashing prior to and following all patient contact; use of gloves for any direct clinical contact; and wearing eye protection in potential splash situations. Depending upon the infectious organism, additional protective measures may be necessary.³⁸ For organisms transmitted by airborne microparticles (including but not limited to mycobacterium TB, measles, varicella), airborne precautions should be exercised, including: 1) Use of a powered air-purifying respirator or a specially fitted mask (N95) respirator with a 5 micron particle filter for any direct patient contact; patients transported with surgical masks in place. 2) Droplet precautions for organisms transmitted by droplets sprayed into the air (including but not limited to mumps, rubella, pertussis, and influenza), including use of a surgical mask within six to ten feet of the patient; patients transported with surgical masks in place. 3) Standard and contact precautions for organisms spread by direct contact (including but not limited to multiple-drug resistant organisms such as methicillin-resistant *S aureus*, vancomycin-resistant enterococci and other organisms such as *C difficile*); a surgical gown must be worn for any direct contact with these patients.

Additional Measures Considering Transmissible Spongiform Encephalopathy

In addition to the basic prevention measures above, additional actions are necessary to protect against exposure to the following infectious particles associated with transmissible spongiform encephalopathy. The most common form of transmissible spongiform encephalopathy is known as Creutzfeldt-Jakob disease, a rapidly progressive and fatal neurodegenerative disorder caused by the production of an abnormal form of a cellular protein known as a prion. The disease has a heritable form, and iatrogenic transmission of Creutzfeldt-Jakob disease has been reported in several hundred patients worldwide, linked to the use of contaminated human growth hormone, dura mater and corneal grafts, or neurosurgical equipment (surgical instruments and stereotactic EEG depth electrodes). No surgery-related cases have been reported since 1976, and no iatrogenic Creutzfeldt-Jakob disease cases have been associated with exposure to prions from environmental contact. Because prions are very resistant to destruction, the most stringent chemical and autoclave sterilization is recommended for instruments in contact with the central nervous system or organ structures of infected patients. These methods include various procedures involving immersion in 1N sodium hydroxide and heat in a gravity displacement autoclave at 121° to 134° C for 30 to 60 minutes, followed by cleaning, rinsing, and routine sterilization. For details the reader is referred to the CDC website at www.cdc.gov.³⁹

Transmission-Based Precautions³⁸

Transmission-based precautions include contact precautions, droplet precautions, and airborne precautions and should *always* be used in addition to standard precautions.

Contact Precautions

Contact precautions help prevent transmission of infectious agents spread by contact with the patient or the patient's environment.

- Use single-patient rooms when possible.
- Maintain ≥3 feet spatial separation between beds in rooms with more than one patient.
- Wear a gown and gloves for all contact with the patient or the patient's environment.

- Wear personal protective equipment before entering the patient's room and discard it before exiting the patient's room.

Droplet Precautions

Droplet precautions help prevent transmission of pathogens spread through close respiratory or mucous membrane contact with respiratory secretions.

- Special air handling and ventilation are not required.
- Healthcare workers should wear a mask prior to entering an infectious patient's room.
- Patients should wear a mask when transported.

Airborne Precautions

Airborne precautions help prevent transmission of infectious agents suspended in the air.

- Place patients in an airborne infection isolation room designed with monitored negative pressure, 12 air exchanges per hour, and air exhausted directly to the outside or recirculated through high-efficiency particulate air filtration.
- Facilities should establish a respiratory protection program.
- Isolate N95 or higher level masked patients in a private room when airborne precautions cannot be achieved.
- Healthcare workers should wear a mask prior to entering an infectious patient's room.
- Immune healthcare workers are the preferred providers for infectious patients with airborne diseases.

Post Exposure Prophylaxis

Mycobacterium tuberculosis (TB)

All healthcare workers-except those who have received the Bacille Calmette Guerin vaccine-should receive an annual TB skin test (an intradermal injection of 0.1 mL of purified protein derived from a sterile extract of the bacillus).⁴⁰ Positive delayed hypersensitivity to the purified protein, manifesting as induration and inflammation, indicates immune system response to a prior exposure to TB. Follow-up to a positive test includes serial chest x-rays and combination drug therapy as recommended by an infectious disease over a period of months. Follow-up sputum testing and chest x-ray will be assessed as recommended. For detailed information, CRNAs are encouraged to review current measures endorsed by the Surgical Care Improvement Project (SCIP), which was created in 2003 by the CMS as an extension of the Surgical Infection Prevention Collaborative.

Hepatitis B Virus (HBV)

All nurse anesthetists should receive the HBV three-dose vaccine series in the deltoid eight weeks apart, resulting in an anti-HBsAg titer within one to two months of >10 mIU/mL plasma. No routine revaccination is recommended. Upon experiencing a high-risk exposure event, the following is recommended: known responder to the vaccine with anti-HBsAg 10 mIU/mL, no treatment; nonresponders or nonvaccinated personnel should receive hepatitis B immune globulin .06 mL/kg IM in the deltoid twice monthly and undergo the vaccination series.⁴¹

Hepatitis C Virus (HCV)

Prevention of exposure through the use of universal precautions, safe handling of sharps, and safe injection practices is the only preventive measure; there is no vaccine or reliable post-exposure prophylaxis. CDC Guidelines recommend an HCV antibody test and alanine aminotransferase level at baseline and at six months to capture the full seroconversion time-window. Polymerase chain reaction testing for HCV may be performed at four to six weeks. Hepatitis C infection is usually asymptomatic. Treatment consists of pegylated interferon and ribavirin, and consistent evidence demonstrates that treatment of acute infections reduces the risk that a chronic infection will evolve.

Human Immunodeficiency Virus (HIV)

The parenteral transmission risk is estimated at 0.3 percent, modified by the size of inoculum, size of needle, and source patient disease status. The mucous membrane splash risk is 0.1 percent. Perform immediate first aid, then seek post-exposure prophylaxis (PEP) drug therapy as soon as possible. Use two-drug PEP for low-risk exposure and three-drug PEP for higher risk exposure over a four-week period. Seek expert opinion to quantify exposure risk. Two-drug regimen: zidovudine + lamivudine (reverse transcriptase inhibitors); three-drug regimen: add lopinavir + ritonavir (protease inhibitors). Take drugs as prescribed, be aware of potential GI side effects such as nausea and fatigue, and monitor liver and renal tests. Private practice CRNAs should consider having PEP drugs on site, or an infectious disease specialist available.⁴²

Influenza Virus

The CDC recommends that all healthcare workers receive an annual flu vaccine. The flu is a contagious respiratory illness caused by the influenza virus. It can cause mild to severe illness, and at times can lead to hospitalization and death. Studies have shown that higher vaccination rates among healthcare workers can reduce the incidence of flu. Annual vaccination is necessary as the flu organism changes rapidly, and vaccination from the previous season may not provide protection. The two types of vaccine are: flu shot (an injection of killed virus approved for people older than 6 months), and nasal-spray (a mist of weakened virus approved for use in healthy people ages 2-49, but not recommended for healthcare workers who may work with severely immunocompromised patients, such as patients receiving organ transplantation or with advanced AIDS).⁴³

Prevention of Ventilator-Associated Pneumonia

Ventilator-associated pneumonia “arises when there is bacterial invasion of the pulmonary parenchyma in a patient receiving mechanical ventilation.”⁴⁴ Inoculation of the formerly sterile lower respiratory tract typically arises from aspiration of secretions, colonization of aerodigestive tract, or use of contaminated equipment or medications. Ventilator-associated pneumonia is a cause of significant patient morbidity and mortality (which may exceed 10 percent), increased use of healthcare resources, and excessive costs of care. Risk factors for ventilator-associated pneumonia include prolonged intubation, feeding tubes, pulmonary aspiration, paralytic agents, underlying severe illness, and extremes of age. CRNAs should consider the role they may play in the prevention of ventilator-associated pneumonia. Ventilator-associated pneumonia prevention measures, called “care bundles,” are presented below:⁴⁴

- Practice hand hygiene prior to and following care
- Use noninvasive ventilation when possible
- Extubate as early as possible
- Prevent aspiration:
 - Maintain patients in semirecumbent position, 30° - 40° if possible
 - Avoid gastric overdistention
 - Avoid unplanned extubation and reintubation
 - Use cuffed endotracheal tube with in-line subglottic suctioning
 - Maintain cuff pressure of at least 20 cm H₂O
- Avoid nasotracheal intubation
- Avoid histamine H₂-blocking agents and proton pump inhibitors if possible due to risk of acid suppressive therapy on bacterial colonization of aerodigestive tract
- Perform regular oral care with an antiseptic solution
- Eliminate contamination of equipment
 - Use sterile water rinse
 - Remove condensate from ventilatory circuit
 - Change circuit only when visibly soiled

- Use sterile sheathe-enclosed suction catheters

Regional Anesthesia

Infection may occur as a complication of any neuraxial regional anesthesia technique. Fortunately, the incidence of severe neurological infection following epidural or spinal anesthesia is exceedingly low.^{30, 36, 45-50} Postdural puncture meningitis (PDPM) is more frequent after spinal anesthesia; epidural or paraspinous abscess is more frequent following epidural block.^{45, 50}

Exogenous inoculation of bacteria into the intrathecal or epidural space may be the result of contaminated medications or instruments, aerosolized organisms, patient skin bacteria, or contaminated practitioner hands.^{36, 45, 46, 51} Bacteria from the mouth and upper airway (e.g., viridans streptococci) are common causative organisms of PDPM.^{50, 52} Skin microorganisms (e.g., *Staphylococcus epidermidis*, *S aureus*, *Staphylococcus hycus*, *Staphylococcus capitis*) are more frequently associated with epidural abscesses.^{45, 48, 50, 53, 54}

Manifestations of PDPM typically appear six to 36 hours after dural puncture,⁴⁵ and are associated with serious sequelae. The subarachnoid space is intentionally entered during diagnostic lumbar puncture procedures, myelograms, and spinal anesthesia, and can be entered inadvertently during epidural blocks. Cases of PDPM have been reported after all of these procedures, but most reported cases of PDPM follow spinal anesthesia.⁴⁵ The true incidence of infective meningitis following spinal block is unknown;⁴⁵ however, outcome data supports a 1:53,000 to 1:10,000 estimated risk.^{45, 50} In one reported case series, over one-third of the patients died after developing PDPM.⁵⁵

Epidural abscess is a medical emergency that if left untreated can result in irreversible neurologic damage. It is more frequent following epidural block and epidural catheter placement.^{45, 50} The true incidence of epidural infection following epidural catheter placement is unknown. Estimates of central nervous system infection associated with epidural catheter placement range from zero to 0.7 percent.^{46, 48, 49, 53, 56} Severe neurological deficit or irreversible paralysis affects 4 percent to 22 percent of patients who develop an epidural abscess associated with anesthesia.^{53, 57} The time interval between catheter insertion and the first symptoms (e.g., fever, backache, neurologic symptoms) of epidural abscess may vary from two days to five weeks.^{50, 58} Compromised immunity, especially diabetes mellitus, is an important risk factor that predisposes a patient to an epidural abscess.^{53, 54, 56} One study concluded that the level of catheter insertion is not directly correlated to the potential for abscess formation.⁵⁶ A prospective review of 8,210 epidurals inserted for postoperative analgesia at a hospital-based acute pain service reported an incidence of epidural abscesses following epidural injection of <0.1 percent.⁵⁹

Key Recommendations for Regional Anesthesia

- Meticulous aseptic technique should always be followed for delivery of neuraxial anesthesia procedures. Aseptic precautions include removal of jewelry (wristwatches, rings), skin preparation and sterile draping around the needle insertion site, wearing caps and masks, thorough handwashing and use of sterile gloves.^{15, 36}

Skin Preparation for Regional Anesthesia

Ineffective skin disinfection before performing a central neuraxial block can place the patient at risk for infection. Faulty decontamination procedures or the use of ineffective skin disinfectant solutions can result in the migration of skin bacteria through needle puncture sites during spinal and epidural placement.^{36, 45, 51}

The skin provides a rich and diverse habitat for bacteria. The most frequently detected organism in the normal skin flora is *S epidermidis*.⁵¹ Despite careful attention to thorough skin disinfection, microorganisms may persist on the skin surface after preparation with a variety of antiseptic solutions.

Resident bacteria on normal skin may lie deep in hair follicles, in orifices of sebaceous glands, or under lipids covering the skin surface. Some disinfectants are unable to fully penetrate the stratum corneum epidermis, which is the outermost layer of the epidermis.⁵¹ Alcohol-based antiseptic solutions are more effective at penetrating the skin and removing microorganisms underneath the skin's surface.³⁶

Some commonly used solutions for skin preparation prior to regional anesthesia are povidone iodine, chlorhexidine gluconate with or without alcohol, iodophor-isopropyl alcohol solution, and isopropyl alcohol alone.

Chlorhexidine gluconate is an effective germicide with a potency that extends several hours beyond the first application to the skin.³⁶ Skin preparation with chlorhexidine gluconate significantly reduces the likelihood of catheter and site colonization after spinal injection procedures. The addition of alcohol to the disinfectant solution provides more rapid and effective germicidal activity.^{36,51} Chlorhexidine 0.5 percent with isopropyl alcohol 70 percent has a rapid and broad spectrum antimicrobial action against nearly all nosocomial yeasts and bacteria (gram-positive and gram-negative). Most randomized controlled trials indicate that skin preparation before epidural catheterization with an alcohol-based chlorhexidine gluconate solution results in a reduced number of positive bacteriologic cultures from the skin and epidural catheters compared with 10 percent povidone-iodine disinfectant.^{51,53,60-62}

Povidone iodine also produces good germicidal activity against many organisms.³⁶ When used for skin decontamination, povidone iodine solutions reduce bacterial growth on the skin and epidural catheters. The addition of alcohol increases the germicidal activity. Randomized controlled trials indicate that povidone iodine with alcohol has greater bacteriocidal effects compared with aqueous povidone iodine without alcohol.⁶⁰ In contrast to most studies, a report by Kasuda, et al indicated that 10 percent povidone iodine produces the same results as 0.5 percent chlorhexidine ethanol when attempting to reduce skin or catheter colonization associated with short-term epidural catheter placement.⁶³ When administering povidone solutions, single-use containers/sachets should be used, as multi-use bottles can become contaminated by bacteria.⁶⁴

Some chlorhexidine-based antiseptic solutions contain the package warning “do not use for lumbar puncture” or “avoid contact with meninges.” These warnings may be based on studies in rats and monkeys, which demonstrated that chlorhexidine in amounts larger than would be used for skin antisepsis produced neurotoxicity and nerve degeneration when in contact with nerve fibers. Based on limited clinical investigations and the manufacturer package warnings, some practitioners avoid the use of chlorhexidine solution for skin preparation prior to neuraxial procedures, despite its superior antiseptic effects.

The escalating use of spinal interventions for pain management and the increasing incidence of antimicrobial resistance to pathogens make adherence to safe injection practices and aseptic technique during neuraxial procedures especially critical.^{38,45,52,65,66}

Key Recommendations for Skin Preparation for Regional Anesthesia⁶⁷

- Antimicrobial skin preparation prior to neuraxial anesthesia delivery is superior with 0.5% chlorhexidine in alcohol. Povidone-iodine with alcohol appears to be a suitable effective alternative.³⁶
- Antiseptics should be allowed to dry according to the manufacturer's recommendation prior to placing the catheter.
- Manufacturer product instructions should be consulted for directions and warnings regarding the proper use and application for specific skin antiseptics.

Barrier Considerations for Regional Anesthesia

Masks

A potential source of bacterial introduction into the intrathecal space is transmission of oral flora from the healthcare provider's upper airway. Organisms can gain entrance into the cerebral spinal fluid via droplets from the airway of healthcare workers and cause meningitis. Large, pliable, pleated, soft facemasks have been shown to effectively limit the spread of droplets arising from the upper airway and reduce bacterial contamination of a surface in close proximity to the upper airway.^{38, 68}

Viridans streptococci are a large group of bacteria that are typically low-grade pathogens in immunocompetent subjects. They are often identified as the causal organisms of meningitis after spinal procedures, accounting for 49 percent to 92 percent of cases of PDPM.^{45, 50, 65, 69} The bacteria can be transmitted from provider to patient by droplet transmission directly from the oropharynx or by contamination of sterile equipment. Cerebral spinal fluid provides an excellent medium for growth of these organisms,^{68, 70} and once in the spinal fluid the bacteria multiply rapidly. Purulent meningitis typically occurs within six to 36 hours after dural puncture and inoculation with a pathogen.⁴⁵ Of five reported cases of PDPM in 2008 and 2009 following intrapartum spinal anesthesia, four were confirmed to have meningitis with *Streptococcus salivarius* infection.⁵² Clusters of streptococcal meningitis following administration of spinal or epidural procedures and myelograms have been reported in cases performed by a common healthcare provider who did not wear a facemask during the procedure.^{52, 69-71} Patients affected with meningitis typically shared identical bacterium strains found in the oral flora of the provider who performed their spinal injection procedure.^{52, 66, 69} The distance of the operator's mouth from the needle's lumen, and the extent to which the operator talks during the procedure, may affect contamination.⁶⁸ Coughing, sneezing, and the presence of pharyngitis or laryngitis in the practitioner may also contribute to contamination.

Droplet transmission of the oral flora to patients during spinal injection procedures places patients at risk for infections such as bacterial meningitis. Although a rare complication, most cases of alpha-hemolytic streptococcal meningitis after lumbar puncture are reportedly caused by dispersal of the organism via droplets from the upper airway of healthcare workers.⁴⁵ In general healthcare practices, surgical masks significantly reduce the likelihood of site contamination from microorganisms grown in the upper airways. Research and case reports show that wearing a face mask maximizes sterile barrier precautions and protects patients from providers with sore throats, those suffering from recurrent tonsillitis, or those who are chronic nasal carriers of *S aureus*.³⁶

In response to several reports of meningitis following myelography procedures, in 2007 the Healthcare Infection Control Practices Advisory Committee recommended for the first time that surgical masks be worn by healthcare providers who were either placing a catheter or injecting material into the spinal canal or epidural space.³⁸ The CDC recommends that facemasks be worn for all spinal injection procedures.⁵²

Key Recommendations for Barrier Considerations for Regional Anesthesia

- In any setting where spinal injection procedures are performed (e.g., acute care facilities, pain management clinics, ambulatory surgery centers), healthcare providers should wear facemasks when performing spinal injection procedures, such as epidural and spinal anesthesia techniques.^{38, 52, 66}
- Large, pliable, pleated, soft facemasks should cover the nose and mouth.^{45, 68}
- Facemasks should be used once and then discarded in the trash at the end of a case or procedure, and a new facemask should be worn for each case or procedure due to reduced efficacy after 15 minutes of wear.^{38, 68, 72}

Gowns

Investigations have not demonstrated that the use of surgical gowns during performance of spinal procedures reduces patient infection and mortality rates. There is currently insufficient data to make definitive recommendations for routine use of sterile gowns during performance of regional neuraxial techniques.^{36, 45}

Gloves

Hands should be decontaminated before donning gloves. Latex gloves have been shown to be more effective than vinyl gloves in reducing hand contamination.³⁶ Promptly remove or replace contaminated gloves and gloves with compromised barrier protection.

Epidural Catheters

Epidural catheters should be inserted using aseptic technique and with the insertion site covered with a sterile occlusive dressing to aid fixation of the catheter and to protect the site from contamination.^{46, 53} A semi-permeable, transparent, adhesive dressing allows visual assessment of the catheter site.^{46, 53} The insertion site and overall patient status should be checked at least daily for early identification of superficial (e.g., erythema, tenderness, or itching at the site) or deep infection (e.g., fever, back pain, lower limb weakness, or headache).^{46, 48}

Chlorhexidine-impregnated dressings used at epidural insertion sites have been shown to reduce epidural skin entry-point colonization.^{73, 74}

Many retrospective reviews, prospective studies, and case reports indicate that infectious complications increase with longer duration epidural catheterization times.^{46, 48, 53, 56, 59} Epidural catheterization for two days or less is associated with a very low incidence of epidural infections.^{53, 56, 58} Cameron, et al reported that site infections typically increase by 40 percent each postoperative day that the epidural catheter is not removed.⁵⁹ There is widespread practice of removing epidural catheters by at least 96 hours after placement.⁵³ However, there are no prospective comparison studies that indicate a definitive duration time associated with infection.

Disconnected Catheters

When a disconnected catheter is discovered and the static fluid state has moved five inches or more from the disconnected end, the catheter should be removed. If a CRNA witnesses the disconnection of a catheter within eight hours of insertion with a static fluid column, a portion of the catheter that is approximately 10 inches from the disconnected end should be cleaned by immersing it in a povidone iodine solution for three minutes. The solution must be completely dry before attempting to “cut the catheter with a sterile instrument in the center of this area and reconnect it with a sterile connector.”³⁶

Key Recommendations for Epidural Catheters

- Epidural catheters should be left in place for the shortest period of time necessary for effective clinical use.
- The patient’s neurologic status and the epidural insertion site should be checked at least daily for early identification of superficial or deep infection.⁴⁶
- When a disconnected catheter is discovered and the static fluid state has moved five inches or more from the disconnected end, the catheter should be removed.

Safe Injection Practices

Safe injection practices and medication handling techniques are intended to protect patients and healthcare providers. Over 130,000 patients’ lives have been threatened by the hepatitis B or C virus due to unsafe injection practices.⁷⁵

HCV is the most common blood-borne infection with approximately 4 million Americans currently harboring the pathogen.^{76,77} In recent years, the transmission of HCV in nonhospital settings is on the rise. Unsafe injection practices have been the source of many HCV outbreaks in the United States.⁷⁷ In 2008, a hepatitis C virus outbreak in Nevada was a direct result of anesthesia professionals reusing syringes and mishandling medication.

The CDC's Safe Injection Practices are intended to protect patients, providers and the public by preventing transmission of infections during patient care in all healthcare settings. The transmission of an infectious disease can be caused by the reuse of the same syringe or needle with multiple patients as well as the improper use of medication vials. The following diagram describes one example of how blood-borne pathogens or other infectious agents may be transmitted.

Unsafe Injection Practices and Disease Transmission

Reuse of syringes combined with the use of single-dose vials for multiple patients undergoing anesthesia can transmit infectious diseases. The syringe does not have to be used on multiple patients for this to occur.

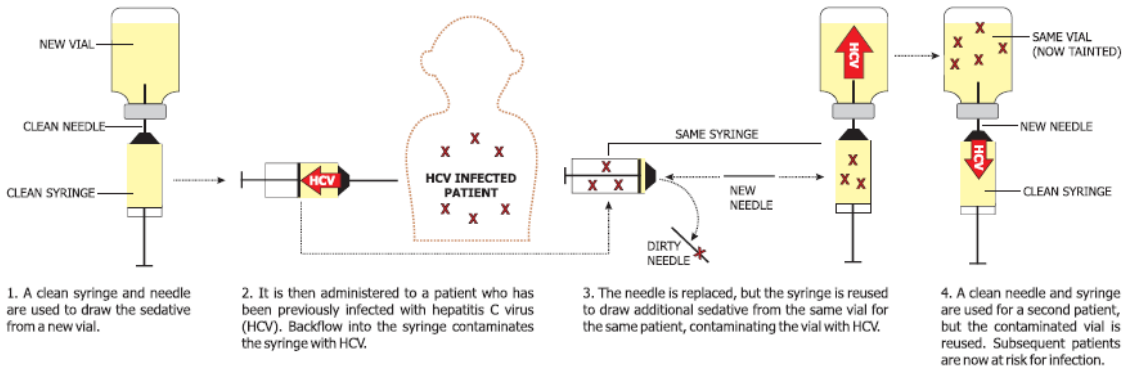


Figure 1

Source: <http://www.southernnevadahealthdistrict.org/download/outbreaks/syringe-graphics-color.pdf>

Used with permission by the Southern Nevada Health District

Safe Practices for Needle and Syringe Use

Standard IX of the AANA's *Scope and Standards for Nurse Anesthesia Practice* details the need for CRNAs and other healthcare providers to take necessary precautions to minimize or prevent the risk of infection to themselves and their patients.⁷⁸ CRNAs practice "in accordance with the professional practice standards established by the profession."⁷⁹ The AANA's position on needle and syringe use is consistent with the CDC's recommended Safe Injection Practices. The AANA's recommendations are briefly outlined below. CRNAs are encouraged to consult AANA's Position Statement 2.13: Safe Practices for Needle and Syringe Use for more detailed information.

Key Recommendations for Safe Injection Practices

- Syringes and needles must *only* be used *once*.
- Never administer medications from the same syringe to multiple patients, even if the needle is changed.
- Never reuse a needle, even on the same patient.
- Never refill a syringe once it has been used, even for the same patient.
- Never use infusion or intravenous administration sets on more than one patient.
- Never reuse a syringe or needle to withdraw medication from a multidose medication vial.

- Never reenter a single-use medication vial, ampoule or solution.
- Medications should be handled and discarded according to the manufacturer’s package insert. Similarly, it is preferred that ointments, gels or lubricants be dedicated to a single patient.

CRNAs and other anesthesia professionals are also encouraged to consult the CDC’s website at http://www.cdc.gov/injectionsafety/IP07_standardPrecaution.html and http://www.cdc.gov/injectionsafety/providers/provider_faqs_multivials.html for complete guidance on safe injection practices. In addition to the AANA’s recommendations, as of July 2011 the CDC also recommends:^{38, 80}

- Use aseptic technique to avoid contamination of sterile injection equipment.
- Use single-dose vials for parenteral medications whenever possible.
- Do not combine leftover medications from single-dose vials/ampoules for later use.
- Do not keep multidose vials in the immediate patient treatment area (e.g., patient rooms or bays, operating rooms, anesthesia carts). While a multidose vial may be placed on an anesthesia cart, once opened or used it should be treated as a single-use vial and discarded at the end of the individual case.
- Multidose vials should be dedicated to a single patient whenever possible.
- Bags or bottles of intravenous solution should not be used as a common source of supply for multiple patients.
- Alcohol concentrations of 70 percent should be used to cleanse the access diaphragms of medication vials before inserting a device or needle into the vial.
- IV pumps must be cleaned and processed according to manufacturer recommendations between patients.

Drug Preparation - USP Chapter <797>

The U.S. Pharmacopeial Convention (USP) is a scientific nonprofit organization responsible for defining standards for medicines and other products using a system of standards and quality control along with a national drug formulary. In the United States, the FDA is responsible for enforcing the USP’s drug standards.

USP General Chapter <797>, *Pharmaceutical Compounding – Sterile Preparations*, is a synthesis of evidence-based practices which provides healthcare workers with minimum practice and quality standards for the delivery of compounded sterile preparations (CSPs). These guidelines apply to all healthcare providers administering CSPs within an institution when that institution has adopted use of Chapter <797>. Federal and state regulatory requirements and accreditation standards may also apply USP <797> guidelines.

All CSPs must be compounded with aseptic manipulations entirely within an ISO Class 5 (using a containment hood or compounding aseptic isolator) or better air quality environment. The only exception to this is the “immediate-use provision” designed for the following situations: cardiopulmonary resuscitation; emergency room treatment; preparation of diagnostic agents; and critical therapy where normal CSP preparation would render more harm to the patient due to delay. Chapter <797> categorizes CSPs into three risk levels (low, medium, and high) and sets preparation standards for each level. Risk levels are defined according to the probability of CSP contamination. Anesthesia medications may meet the “immediate use provision” if the delay from preparation of CSPs following the preparation standards of a low-risk level drug would render additional risk to the patient. Medium- and high-risk CSPs cannot be prepared under the immediate-use provision. CSPs prepared using the immediate-use exception may not be stored or prepared by batch compounding.

The following criteria for low-risk CSPs must be met to qualify for the immediate-use provision:⁸¹

1. The CSP should have no more than three commercially manufactured packages of sterile nonhazardous products from the manufacturer's original container, and no more than two entries into a sterile administration container/device or sterile infusion solution.
2. The compounding procedure is continuous and does not exceed one hour.
3. Aseptic technique is followed and the prepared CSP is under continuous supervision until administered. Administration begins no later than one hour following the start of the CSP preparation.
4. The CSP must be labeled with patient identification information, the names and amounts of all ingredients, the name or initials of the CSP preparer, and the exact beyond-use date and time, unless the CSP is immediately and completely administered by the CSP preparer *or* unless immediate and complete administration of the CSP is overseen by another preparer.
5. If the prepared CSP administration has not started within one hour following the start of preparation, the CSP must be promptly, properly, and safely discarded.

Daily anesthesia workflow makes the immediate-use provision challenging to meet as providers are prohibited from batch medication preparation. All personnel involved in compounding should understand how they may contribute to the risk of CSP contamination during preparation. To decrease the risk of contamination, many hospital pharmacies commonly prepare medications used in delivery (e.g., phenylephrine) or buy ready-to-use, prefilled medications (e.g., fentanyl, sufentanil). Anesthesia professionals should prepare CSPs using proper aseptic technique.

Arterial Catheters and Pressure Monitoring Devices for Adult and Pediatric Patients

Arterial catheters (A-lines) allow continuous beat-to-beat blood pressure monitoring and provide access for arterial blood gas sampling. Arterial catheters are usually inserted into the radial or femoral artery. The risk of catheter-related blood stream infection (CRBSI) from arterial catheter placement is lower than that associated with noncoated central vascular catheters (CVCs) (1.7 versus 2.7 per 1,000 catheter days), with the risk of CRBSI being more comparable between arterial catheters and coated CVCs.⁸²

A very low risk of CRBSI (0.41/1,000 catheter days)⁶⁷ results when A-lines are inserted using maximum barrier precautions. A meta-analysis failed to show significant variable rates of CRBSI between radial, femoral, or axillary insertion sites. The CDC reports catheter colonization by gram-negative bacteria most frequently is found at the femoral site, thus recommends that femoral A-lines should be avoided in adults unless medically indicated.⁶⁷ Long-term arterial canalization among ICU patients showed similar rates of catheter colonization and CRBSI between both the radial and dorsalis pedis sites.⁸³ As with all intravascular catheters, the risk of developing a CRBSI is directly proportional to the duration of catheterization. Risk of infection is also increased with routine changing of catheters. To minimize this risk, catheters that need to be in place for >5 days should not be routinely changed if no evidence of infection is observed.⁶⁷ Complete guidance on infection control practices during arterial line insertion can be found in the CDC's Guidelines for the Prevention of Intravascular Catheter-Related Infections (available at: <http://www.cdc.gov/hicpac/bsi/bsi-guidelines-2011.html>).

Key Recommendations for Arterial Catheters and Pressure Monitoring Devices for Adult and Pediatric Patients

- In adults, use of the radial, brachial or dorsalis pedis sites is preferred over the femoral or axillary sites of insertion to reduce the risk of infection.
- In children, the brachial site should be avoided if possible. The radial, dorsalis pedis, and posterior tibial sites are preferred over the femoral or axillary sites of insertion.

- A minimum of a cap, mask, sterile gloves and a small sterile fenestrated drape should be used during peripheral arterial catheter insertion (usually inserted in the radial artery, it can also be placed in the femoral, axillary, brachial, and posterior tibial arteries).
- Sterile gloves should be worn.
- Catheters that need to be in place for >5 days should not be routinely changed if no evidence of infection is observed.
- During axillary or femoral artery catheter insertion, maximal sterile barrier precautions, including the use of a cap, mask, sterile gown, sterile gloves, and a sterile full-body drape, should be used.
- Replace arterial catheters only when there is a clinical indication.
- Remove arterial catheters as soon as they are no longer needed.
- Use disposable, rather than reusable, transducer assemblies when possible.
- Replace disposable or reusable transducers at 96-hour intervals. Replace other components of the system (including the tubing, continuous-flush device, and flush solution) at the time the transducer is replaced.
- Keep all components of the pressure monitoring system sterile (including calibration devices and flush solution).
- Minimize the number of manipulations of and entries into the pressure monitoring system. Use a closed flush system (i.e., continuous flush), rather than an open system (i.e., one that requires a syringe and stopcock), to maintain the patency of the pressure monitoring catheters.
- Stopcocks should be kept free of blood and covered by a sterile cap or syringe when not in use.
- Before use check all containers of parenteral fluids for visible turbidity, leaks, cracks, particulate matter, and the manufacturer's expiration date.
- Stopcocks, injection ports, and other portals of access to sterile fluids should be maintained with sterile and aseptic techniques.
- IV injection ports should be cleaned with 70 percent isopropyl alcohol prior to entry.
- The vial's rubber stopper should be disinfected with 70 percent isopropyl alcohol before accessing.
- When the pressure monitoring system is accessed through a diaphragm rather than a stopcock, scrub the diaphragm with an appropriate antiseptic before accessing the system.
- Do not administer dextrose-containing solutions or parenteral nutrition fluids through the pressure monitoring circuit.
- Sterilize reusable transducers according to the manufacturer's instructions if the use of disposable transducers is not feasible.

Central Line Insertion

More than 15 million days of total exposure to CVCs occur across the United States annually.⁸⁴ Many studies have been conducted that have focused on CRBSIs. The CDC defines a CLABSI as recovery of a pathogen from a blood culture (a single blood culture for organisms not commonly present on the skin, and two or more blood cultures for organisms commonly present on the skin) taken from a patient who had a central line at the time of infection or within the 48-hour period before development of infection. According to the CDC, "The infection cannot be related to any other infectious process the patient may have and must not have been present or incubating when the patient was admitted to the facility."⁸⁵ The CDC reports that approximately 41,000 CLABSIs are identified in hospital settings annually.⁸⁵

Every year in the United States, approximately 5 percent of hospital admissions are associated with HAIs.⁸⁵ Of the roughly 250,000 to 500,000 cases of blood stream infections that occur in the total number of hospitalized patients from all units every year,^{82, 86} CRBSIs possess mortality rates between 12 percent and 25 percent per infection.⁸⁶ Additionally, 60 percent of isolates acquired from central lines of ICU patients show methicillin-resistant *S aureus* cultures.⁸⁷

Four confirmed mechanisms for the contamination of intravascular catheters have been identified. The most common source of contamination for CLABSIs is due to extraluminal catheter surface contact with skin flora. The organisms normally found on the skin migrate into the cutaneous catheter tract and across the length of the catheter, eventually colonizing at the tip of the catheter.⁶⁷ A second route of contamination occurs when a provider's hands or contaminated fluids or devices come into direct contact with the catheter or catheter hub.⁶⁷ A less common route of infection may be attributed to intraluminal surface contamination due to hematogenous spread from another infection (e.g., respiratory, urinary infections).^{67, 88} Finally, contaminated infusate being administered via the CVC may lead to a CRBSI, although this is rare.⁶⁷ Short-term catheter-related infections are more often related to extraluminal catheter colonization with skin flora, whereas long-term catheter-related infections are usually related to intraluminal colonization.⁸⁹ Typical causative organisms are *staphylococci*, enterococci, *S aureus*, and *Candida*. Approximately 20 percent of CLABSIs are due to gram-negative bacilli.⁶⁷

CVCs should also be inserted using aseptic technique and the insertion site should be covered with a sterile, semi-permeable, transparent adhesive dressing. The site where a CVC is placed influences the risk of CRBSI. Although no randomized controlled trials have successfully evaluated the rate of infection at various catheter insertion sites, retrospective observational studies have shown that the internal jugular catheter insertion site typically promotes a higher risk for colonization and/or CRBSI than subclavian insertions.⁶⁷ Although studies in pediatric populations have demonstrated that femoral vein catheters have a low rate of complications, they should be avoided in adults due to the higher risk for deep venous thrombosis.⁶⁷ Studies also found that two-dimensional ultrasound use for CVC placement significantly decreases mechanical complications and failed cannula insertion attempts.⁶⁷ All catheter placements should be performed as atraumatic as possible to prevent accidental puncture of the vein or artery resulting in the formation of a subcutaneous hematoma.⁹⁰

The material of which CVC devices are constructed is an important pathogenic determinant of CRBSIs. Polytetrafluoroethylene or polyurethane catheters are associated with fewer infection rates than those constructed from polyvinyl chloride or polyethylene.⁶⁷

Risk factors for CRBSIs include the following:⁹¹

- Femoral >internal jugular >subclavian catheterization
- Duration of catheterization >= eight days
- Polyvinyl chloride or polyethylene catheters
- Frequent manipulations
- Improper aseptic technique during insertion
- Increasing number of catheter lumens
- Use of the catheter for total parenteral nutrition
- Foreign body-related tissue damage

Comorbidities that may predispose a patient to develop CRBSIs as a result of a compromised immune system include:⁹⁰

- Diabetes Mellitus
- History of drug abuse
- Steroid or other immunosuppressive therapy
- Malignancy
- Pregnancy
- HIV infection
- Alcoholism
- Liver disease

Several practices have been proven to decrease the rate of CRBSIs. Proper hand hygiene with soap and water or an alcohol-based sanitizer may be the most important factor. A trial comparing the use of maximum sterile barrier precautions versus sterile gloves and a small drape during the insertion of a central line found that the maximum sterile barrier group had less catheter colonization with gram negative microbes. Infections also occurred much later in the maximum sterile barrier group.⁶⁷ The use of an antimicrobial or antiseptic-impregnated CVC (i.e., chlorhexidine/silver sulfadiazine or minocycline/rifampin) in adults whose catheter is expected to remain in place more than five days reduces the rate of CLABSIs with a potential cost savings.⁶⁷

In efforts to both improve patient outcomes and attenuate excess medical expenses, there is a movement among healthcare providers, insurers, regulators, and patient advocates to reduce the incidence of CRBSIs which can only be achieved through a team effort.

In 2009, approximately 18,000 CLABSIs occurred in intensive care units as compared to the 43,000 CLABSI cases that occurred in 2001, a 58 percent decrease.⁸⁵ This translates to about 6,000 lives saved and a \$414 million dollar savings in healthcare costs in 2009 alone.⁸⁵

As the evidence associated with this issue continues to evolve, CRNAs should take steps to familiarize themselves with the appropriate expert sources of information for this rapidly evolving science. The following recommendations are not all inclusive and do not attempt to detail every recommendation for central venous catheters. Complete guidance on infection control practices during central line insertion can be found in the CDC's Guidelines for the Prevention of Intravascular Catheter-Related Infections (available at: <http://www.cdc.gov/hicpac/bsi/bsi-guidelines-2011.html>).

Key Recommendations for Central Line Insertion

- Hand hygiene should be performed before and after palpating catheter insertion sites as well as before and after inserting, replacing, accessing, repairing, or dressing an intravascular catheter.
- Use maximal sterile barrier precautions, including the use of a cap, mask, sterile gloves, sterile gown and a sterile full body drape for the insertion of CVCs, peripherally inserted central catheters, or guidewire exchange.
- Use an antimicrobial or antiseptic-impregnated CVC (i.e., chlorhexidine/silver sulfadiazine or minocycline/rifampin) in adults whose catheter is expected to remain in place more than five days.
- Clean the skin with a >0.5 percent chlorhexidine preparation with alcohol before central venous catheter and peripheral arterial catheter insertion and during dressing changes. If there is a contraindication to chlorhexidine, alternatives that can be used are iodine, an iodophor, or concentrations of 70 percent alcohol.
- Replace damp, wet, or soiled catheter dressings.
- Avoid topical antibiotic ointment and creams on insertion sites (except for dialysis).
- Use a subclavian site, rather than a jugular or a femoral site, in adult patients to minimize infection risk for nontunneled CVC placement if possible.
- Avoid using the femoral vein for central venous access in adult patients if possible.
- When adherence to aseptic technique cannot be ensured (e.g., catheters inserted during a medical emergency), replace the catheter as soon as possible (i.e., within 48 hours).
- Use ultrasound guidance to place central venous catheters (if this technology is available) to reduce the number of cannulation attempts and mechanical complications.
- Use polyurethane catheters rather than polyvinyl chloride or polyethylene catheters if possible.
- Be aware that routine replacement or rewiring of CVCs does not prevent CRBSIs and is associated with increased mechanical complications.
- Promptly remove nonessential IV catheters.

- Replace short-term CVCs where infection is suspected.
- Use a guidewire exchange to replace inoperable, nontunneled, noninfected catheters.
- Use sterile sleeves when inserting pulmonary artery catheters.

Perioperative Antibiotic Therapy Surgical Care Improvement Project Measures and Surgical Site Infection Prevention

The administration of perioperative antibiotic therapy is an effective strategy for the prevention of surgical site infection.⁹ The recommended use of prophylactic antimicrobial therapy is supported as part of SCIP. Three performance measures for quality improvement related to antimicrobial prophylaxis were identified:

1. Delivery of intravenous antimicrobial prophylaxis within one hour prior to incision, recognizing that two hours may be allowed for the administration of vancomycin and fluoroquinolones;
2. The antimicrobial prophylactic agent used should be in accordance with published guidelines (see Appendix 1 of this guide); and
3. Prophylactic antimicrobial therapy should be discontinued within 24 hours after surgery, recognizing that 48 hours is allowable for cardio-thoracic procedures in adult patients.

Key Recommendations for Perioperative Antibiotic Therapy Surgical Care Improvement Project Measures and Surgical Site Infection Prevention⁹

- Use proper hair removal methods to ensure the preservation of skin integrity (e.g., avoid the use of razors or depilatories).
- Control the blood glucose level during the immediate postoperative period for cardiac surgery patients with 0600 blood glucose < 200 mg/dL on postoperative days one and two.
- Maintain perioperative normothermia for patients undergoing colorectal surgery.

Preventive Measures: Procedural

Anesthesia equipment is a potential vector for transmission of nosocomial infections. This section provides information necessary to practice appropriate infection control measures with regard to the anesthesia machine system and surfaces, patient circuit, bacterial filters, heat and moisture exchangers, as well as single-use items and reprocessing practices. Sterilization, as the name implies, destroys all forms of microbial life and involves chemical or physical methods. Disinfection, on the other hand, eliminates most pathogenic microorganisms with the exception of bacterial spores and prions. Disinfection is divided into three categories: low-, intermediate-, and high-level disinfection. Low-level disinfection destroys most vegetative bacteria (except tuberculosis) and the lipid or medium-sized viruses (HIV, herpes, hepatitis B). Intermediate-level disinfection destroys nonlipid or small viruses (polio, coxsackie) and most fungi. High-level disinfection destroys mycobacteria but not all endospores, fungi and viruses.^{92,93} See Appendix 2 of this guide.

Approaches to Disinfection and Sterilization

The most important step in decontamination is cleaning (the removal of visible soil). This step is critical because the presence of proteins, salts and other organic products on equipment can interfere with or inactivate the chemical germicides used in the disinfection process and interfere with sterilization. The efficacy of the disinfection and sterilization process is affected by the organic and inorganic load present, type and level of microbial contamination, concentration and exposure time to germicide, physical nature of the device, biofilm presence, temperature and pH of the disinfection process and, in some instances, relative humidity of the sterilization process.⁹² See Appendix 3 of this guide. Retained residues may interfere with the function of the device or lead to an undesirable reaction in the patient.

Organic matter that dries on equipment is difficult to remove thoroughly during the cleaning process. Enzymatic sprays may be used to break down organic substances and prevent drying. Lumens may be flushed with enzymatic cleaners. Immersible items can be soaked in appropriate cleaners as recommended by the Environmental Protection Agency (EPA) and manufacturers and in accordance with CDC guidelines.

Equipment is then disassembled, rinsed with protein-dissolving solution, soaked and scrubbed. This is followed by rinsing with water to remove organic debris as well as residual cleaner. The equipment is then thoroughly dried and inspected for cleanliness and functionality. When indicated, the equipment may then be sterilized.

Disinfection and sterilization procedures for individual equipment vary and are dependent upon the device as well as the manufacturer. For this reason, the AANA has not detailed specific recommendations for preferred chemical agents or methods. Selection of cleaners and choice of sterilization and disinfectant (an antimicrobial agent that is applied to inanimate objects) as well as duration of exposure should be made with consideration of manufacturer guidelines and EPA, FDA and CDC recommendations. Facilities should establish a routine disinfection program and a method for monitoring compliance.^{80,92} Methods of disinfection and sterilization as recommended by the CDC are located at http://www.cdc.gov/hicpac/Disinfection_Sterilization/13_0Sterilization.html. See Appendix 4 of this guide for properties of an ideal disinfectant.

The Spaulding scheme is a classification system used to identify how medical equipment should be disinfected and sterilized based on degree of risk of infection. Guidelines for disinfection and sterilization are based, in part, on the Spaulding scheme and are listed below.^{80,92}

Critical Items

This category includes objects that come in contact with the vascular system or any sterile body cavity. Critical items, if contaminated, have a high risk of infection and disease transmission. This includes regional and vascular needles as well as catheters. These items necessitate sterility at the time of use.

Semicritical Items

This category covers objects that come in contact with but do not pierce mucous membranes or nonintact skin, including but not limited to: laryngoscopes, endoscopes, laryngoscope blades, oral and nasal airways, resuscitation bags, face masks, endotracheal tubes and connectors, breathing tube components and connectors, and esophageal stethoscopes. Ideally, these items should be sterile when possible. At a minimum, these items require high-level disinfection. These items should be dried and stored in a manner that prevents recontamination.

Noncritical Items

This category covers objects that come in contact with intact skin, not mucous membranes, and includes but is not limited to: blood pressure cuffs, stethoscopes, arm boards, pulse oximeter sensors, electrocardiogram electrodes, all associated cables, head straps, blood warmers, carbon dioxide absorber systems, medication administration pumps, equipment carts, and monitors. Cleaning followed by intermediate- or low-level disinfection is indicated. “Virtually no risk has been documented for transmission of infectious agents to patients through noncritical items when they are used as noncritical items and do not contact non-intact skin and/or mucous membranes.”⁹²

Environmental Surfaces

This category covers the surfaces of medical equipment, knobs, table tops, anesthesia carts, laryngoscope handles, monitoring cables, pumps and other equipment not in direct contact with the patient. Cleaning with an intermediate- or low-level disinfectant should provide adequate decontamination. Each facility should choose an EPA-registered disinfectant or detergent that has been approved for use in a healthcare setting. Facilities should follow manufacturer recommendations regarding use, exposure time, disposal, etc., of the disinfectant or detergent as appropriate. Each facility should establish a protocol for frequency of disinfection as well as monitoring for compliance and efficacy.^{80, 94, 95}

The Spaulding classification scheme has limitations, however. The scheme is oversimplified and does not specifically address issues related to reprocessing complicated medical devices that are heat sensitive or issues linked to certain infectious organisms such as prions associated with Creutzfeldt-Jacob disease. Lastly, it does not specifically address instruments from two different categories that are used in conjunction with one another. Facilities should establish disinfection and sterilization guidelines that are in concordance with CDC guidelines and with FDA-approved agents and methods to reduce the level of variance among institutional practices. Manufacturers are requested by the FDA to list at least one protocol for cleaning and disinfection/sterilization in product labeling.⁹²

Key Recommendations for Approaches to Disinfection and Sterilization

- Items classified as critical by the Spaulding scheme necessitate sterility at the time of use.
- At a minimum, semi-critical items require high-level disinfection and should be dried and stored in a manner that prevents recontamination.
- Noncritical items should be cleaned followed by intermediate- or low-level disinfection as indicated.
- Facilities should establish a routine disinfection program and a method for monitoring compliance.^{80, 92}

Anesthesia Machine Surfaces and Other Environmental Surfaces

The anesthesia machine does not come in direct contact with the patient. However, there is considerable potential for pathogen exposure from the machine to the patient as organisms are carried by the anesthetist's hands.^{96,97} Disinfectants must be used effectively to prevent HAIs.⁹² Highly contaminated work areas have been demonstrated to increase the potential for healthcare acquired infections.⁹⁸ The anesthesia machine surfaces and knobs should be cleaned between cases with particular attention paid to knobs that are used frequently as they are most likely to be contaminated with pathogens.^{80,96} Items that may be used during the next case should be placed on clean surfaces. Surfaces should undergo cleaning and disinfection regularly or after visible contamination with blood and body fluids or other organic matter.⁹² Surfaces may be sprayed or wiped with a low- or intermediate-level disinfectant as recommended by manufacturer guidelines and the EPA and approved by the facility. Abrasive cleaners should be avoided as they may scratch the surfaces of the machines and create surfaces where pathogens may accumulate. Wiping down surfaces with 70 percent isopropyl alcohol has been determined to reduce bacterial contamination of these surfaces and may be a useful additional step.⁹⁹ Disadvantages of alcohol are flammability, rapid evaporation which makes extensive exposure time difficult, and potential for damage to equipment.⁹² Other environmental surfaces such as intravenous and epidural pumps, blood glucose meters and other point-of-care devices, stand alone monitors, blood and fluid warmers, and forced air warmers should be cleaned and reprocessed appropriately as well.⁸⁰ CRNAs should recognize that materials stored on the anesthesia machine may become inadvertently contaminated by other airborne debris (e.g., blood) during the operative procedure, and therefore, should take protective measures to prevent this. If contamination is suspected, the materials should be cleaned or discarded.

Key Recommendations for Anesthesia Machine Surfaces and Other Environmental Surfaces

- Anesthesia machine surfaces and knobs should be cleaned between cases with particular attention paid to knobs that are used frequently as they are most likely to be contaminated with pathogens.^{80,96}
- Surfaces should undergo cleaning and disinfection regularly or after visible contamination with blood and body fluids or other organic matter.⁹²
- Avoid abrasive cleaners.

Anesthesia Machine System

Specific instructions provided by the manufacturer for cleaning and disinfecting the anesthesia machine should be followed. From these guidelines, the department or facility responsible for administration of anesthetics should establish an infection control policy with monitoring procedures for efficacy and compliance. In general, only the components on the patient side of the fresh gas outlet require sterilization.

The patient circuit is composed of all components that directly communicate with the patient's respiratory system. These include the carbon dioxide absorber, canister, unidirectional valves, breathing circuit, APL valve, water trap, ventilator bellows and rebreathing bag. Routine daily sterilization and high-level disinfection of the internal components of the anesthesia machine system are not necessary as long as a bacterial/viral filter has been placed between the patient and the anesthesia machine system.

Facilities should establish protocols for periodic cleaning and disinfection that are in accordance with manufacturer recommendations.⁹³

Nurse anesthetists should follow manufacturer instructions regarding periodic disassembly and disinfection of adjustable pressure-limiting valves. Some valves may be autoclaved and some may be pasteurized.

Carbon dioxide and soda lime absorbers should be cleaned when the absorber is changed and debris should be removed from the screens. The canisters themselves have specific sterilization guidelines depending upon the manufacturer, as some materials may be damaged by heat sterilization. Some anesthesia machines use disposable plastic canisters filled with absorber. These can be discarded after use and a specific cleaning process is not indicated.¹⁰⁰ Reservoir bags are commonly supplied with patient circuits and are disposable.

Adaptors such as positive end-expiratory pressure valves should be rinsed, soaked in a detergent solution, and washed either manually or mechanically. Rubber or plastic adaptors may be sterilized with ethylene oxide, plasma sterilization, or in a liquid such as glutaraldehyde. Metal adaptors may be autoclaved or pasteurized.

In addition to the commonly recognized components of the patient circuit, a number of other components come in contact with respiratory secretions. These items require appropriate cleaning, disinfecting, and sterilizing when indicated. Water trap components found in respiratory gas monitors, sensors and probes, special nonbreathing system manifolds and adapters, spirometers, and other breathing circuit accessories should also be decontaminated and sterilized according to instructions provided by the manufacturer.

In most cases, the waste gas scavenging components do not need to be sterilized following use on an infected patient provided that the appropriate use of a bacterial filter was implemented. The scavenging equipment should be washed in detergent solution (as approved by the manufacturer) periodically and connecting hoses should be changed at that time.

Key Recommendations for the Anesthesia Machine System

- Specific instructions provided by the manufacturer for cleaning and disinfecting the anesthesia machine should be followed.
- Facilities should establish protocols for periodic cleaning and disinfection that are in accordance with manufacturer recommendations.⁹³
- Carbon dioxide and soda lime absorbers should be cleaned when the absorber is changed and debris should be removed from the screens.
- Adaptors such as positive end-expiratory pressure valves should be rinsed, soaked in a detergent solution, and washed either manually or mechanically.
- Components that come in contact with respiratory secretions require appropriate cleaning, disinfecting, and sterilizing when indicated.

Heat and Moisture Exchangers, Anesthesia Circuits, and Breathing System Filters

Heat and moisture exchangers warm and humidify exhaled air. However, these exchangers alone have not been demonstrated to be effective in decreasing the transmission of microbes to the anesthesia breathing system.^{101, 102} A heat and moisture exchanger may or may not be equipped with a filtering medium designed to entrap bacteria or viral contaminants.

Anesthesia circuits may be manufactured as either single patient use items or multiple patient use items (provided that a new breathing system filter is placed between the y-piece and the artificial airway after each patient). CRNAs should pay close attention to anesthesia circuit product labeling. It is important to note that the outer surface of the circuit may have contamination when the system is not changed between patients.

Breathing system filters, when used, should be placed between the artificial airway and the anesthesia machine system. Breathing system filters are single patient use items. Filters have been demonstrated to isolate microbes and therefore reduce transmission of bacteria and other pathogens to the anesthesia

machine system.^{103, 104} However, at this time conclusive evidence that the use of filters during anesthesia directly reduces the incidence of ventilator-associated pneumonia is lacking.¹⁰⁵

Key Recommendation for Heat and Moisture Exchangers, Anesthesia Circuits, and Breathing System Filters

- Breathing system filters, when used, should be placed between the artificial airway and the anesthesia machine system.

Oral Airways and Suction Devices, Stylets, Bougies, Endotracheal Tubes and Connectors and Laryngoscope Blades

Most oral airways and suction devices are disposable and should be treated as clean objects. They should not be allowed to drop on the floor and they should be discarded. Stylets are most commonly supplied as sterile, disposable and for single patient use. Endotracheal tubes and connectors also are commonly supplied as sterile and for single patient use. Reusable gum elastic bougies are sources for microbial cross contamination and microbial organisms have been isolated from these devices.¹⁰⁶ These devices should be cleaned, undergo high-level disinfection, and then be sterilized with manufacturer approved agents. Reprocessed laryngoscope blades, as well as other semi-critical equipment, should then be packaged and stored in a manner so that recontamination is prevented. For example, a method of proper packaging and storage of a laryngoscope blade is a peel pack post steam sterilization. In contrast, leaving such equipment loose and unpackaged in the drawer of the anesthesia cart is not considered an appropriate method of packaging and storage. Performing safety checks of the laryngoscope blade to ensure proper functioning of the light source is acceptable as long as proper hand hygiene occurs and the laryngoscope blade is immediately returned to its original packaging or other packaging that prevents contamination.

Rigid Laryngoscopes

Numerous studies have demonstrated that contamination of laryngoscope blades and handles is common.^{107, 108} The handle and the blade are considered contaminated after patient use. They should not be placed on a clean surface. At a minimum, the handle should be wiped with a low-level disinfectant after use.¹⁰⁷ The laryngoscope blade itself requires high-level disinfection followed by sterilization. Several different sterilization methods may be employed. It is important to note that the newer fiberoptic blades are composed of light transmitting fibers that are heat sensitive and rapidly degrade during the autoclaving process.¹⁰⁹ Disposable handle covers and disposable blades are a reasonable option when there is potential for prion contamination.

Supraglottic Airway Devices

Studies have demonstrated that laryngeal mask airways (LMAs) frequently are contaminated with occult blood after patient use. Reusable LMAs should be rinsed after removal and soaked in enzymatic detergent. Proteins are then scrubbed off and the LMA is rinsed, dried, and autoclaved. Manufacturer's specifications should be followed for the disinfection and sterilization process. However, it has been demonstrated in numerous studies that protein deposits are extremely difficult to eradicate completely from reusable LMAs regardless of disinfection and sterilization methods employed.¹¹⁰⁻¹¹⁴ Because of this, it is reasonable to preferentially use the disposable LMAs that are currently manufactured.

Flexible Bronchoscopes and Ultrasound Probes

Flexible bronchoscopes require meticulous cleaning and high-level disinfection, at a minimum, after each use. Flexible endoscopes are difficult to disinfect because of their design and use of delicate fiberoptic materials.⁹² Reports of *Pseudomonas aeruginosa* infections have been documented in facilities where proper bronchoscope cleaning and disinfection techniques were not employed.¹¹⁵ Ultrasound probes used for transesophageal echocardiograms should be treated as semi-critical devices. These items should undergo high-level disinfection at a minimum. Ultrasound probes that come in contact with sterile body

sites (i.e., intracavitary) may be covered with a sterile sheath to reduce the level of contamination on the probe. However, a sheath does not definitively protect the device from contamination. The sheath may be punctured inadvertently, for example. The probe should undergo high-level disinfection at a minimum and be covered with a new sterile probe cover when reused.⁹² Reprocessed bronchoscopes and ultrasound probes should then be stored in a manner that prevents recontamination and promotes drying.

Key Recommendations for Oral Airways and Suction Devices, Stylets, Bougies, Endotracheal Tubes and Connectors, Laryngoscopes, Bronchoscopes and Ultrasound Probes

- Reusable gum elastic bougies are sources for microbial cross contamination and microbial organisms have been isolated from these devices.¹⁰⁶ These devices should be cleaned, undergo high-level disinfection, and then be sterilized with manufacturer approved agents.
- Reprocessed laryngoscope blades, as well as other semi-critical equipment, should then be packaged and stored in a manner so that recontamination is prevented.
- Laryngoscope blades and handles should not be placed on a clean surface.
- At a minimum, the handle should be wiped with a low-level disinfectant after use.¹⁰⁷ The laryngoscope blade itself requires high-level disinfection followed by sterilization.
- Reusable LMAs should be rinsed after removal and soaked in enzymatic detergent.
- Flexible bronchoscopes require meticulous cleaning and high-level disinfection, at a minimum, after each use.
- Ultrasound probes used for transesophageal echocardiograms should undergo high-level disinfection at a minimum and be covered with a new sterile probe cover when reused.⁹²

Ancillary Instruments

Ancillary instruments that come in direct contact with the patient's mucous membranes should be decontaminated with a detergent and water solution and then subjected to high-level disinfection or sterilized prior to reuse. This includes but is not limited to Magill forceps.

Instruments that come in contact with the patient's intact skin should be decontaminated with an EPA-approved liquid detergent or disinfectant, rinsed thoroughly, and then dried. This includes but is not limited to noninvasive blood pressure cuffs, monitor cables, pulse oximeter probes, precordial stethoscopes, ultrasound probes, and roll boards used to transfer patients.¹¹⁶⁻¹¹⁸ Stethoscopes have been shown to support microbial growth and are therefore a potential vector for cross contamination. Stethoscopes can be washed and then cleaned with 70 percent isopropyl alcohol prior to patient use.¹¹⁹ Healthcare workers should minimize the amount of personal equipment (e.g., stethoscopes) brought into the operating room environment. Personal items that are used should be cleaned between patients.

Key Recommendations for Ancillary Instruments

- Ancillary instruments that come in direct contact with the patient's mucous membranes should be decontaminated with a detergent and water solution and then subjected to high-level disinfection or sterilized prior to reuse.
- Instruments that come in contact with the patient's intact skin should be decontaminated with an EPA-approved liquid detergent or disinfectant, rinsed thoroughly, and then dried.
- Personal items that are used should be cleaned between patients.

Single-use Items: Disposable Products and Reuse

“Reuse of single-use devices involves regulatory, ethical, medical, legal and economic issues and is controversial.”⁹² A guidance document released by the FDA in 2000 specified that hospitals or other third-party reprocessors are considered manufacturers and are thus subject to the same regulations and standards as the original manufacturers. Due to the controversy surrounding this issue, CRNAs are encouraged to refer to the FDA for latest recommendations (www.fda.gov).⁹²

Preventive Measures: Environmental

Infection control is a worldwide issue that CRNAs and other members of the healthcare team must collectively work to address. There are many factors that play a role in infection control and prevention, including good housekeeping and laundering practices, proper hand hygiene, use of personal protective equipment, and appropriate disposal of infectious and biohazardous waste. Infection transmission in the operating room environment can be reduced or prevented when appropriate safeguards and precautions are implemented and must be a priority in all settings where patient care is provided. Research confirms that hand hygiene and thorough cleaning of environmental surfaces reduce HAIs from being transferred from surfaces to providers and their patients.⁹⁸ CRNAs shall follow universal precautions whenever caring for patients, and follow facility housekeeping practices and procedures.

Housekeeping Practices for Environmental Surfaces

In compliance with the Occupational Safety and Health Administration (OSHA) Bloodborne Pathogens Standard and its intention to protect all healthcare workers from the risk of infection and transmission of bloodborne pathogens, certain housekeeping policies shall be implemented in all anesthetizing locations in accordance with a facility-developed schedule.

1. Anesthetizing locations should be maintained in a clean and sanitary condition. Appropriate written scheduling for cleaning, decontamination, disinfection, and sterilization should be determined by facility policy. The housekeeping method should be implemented based on the type of surface or component to be cleaned, type and amount of soiling present, and room contamination level.
2. Environmental surfaces (e.g., anesthesia carts, floors) are considered noncritical surfaces requiring low-level disinfection. When equipment and environmental surfaces are visibly contaminated with blood, body fluids or other potentially infectious materials, or are soiled with or used in the presence of infectious materials, decontamination should be performed immediately following a procedure.
3. Work surfaces and portable equipment (e.g., telephones, computer keyboards) can become contaminated with toxins¹²⁰ and should be cleaned and decontaminated regularly with an appropriate low-level disinfectant (e.g., detergent) when visibly soiled and after completion of all procedures. Certain pathogens can survive for long periods on environmental surfaces if not treated appropriately.⁹² Generally, the type of surface to be cleaned and the amount and type of soil are important in determining the appropriate EPA-registered cleaning and disinfectant solutions. Facility policy should specify the selection of and frequency of use of cleaning agents. Effective cleaning and disinfecting of environmental surfaces also reduces the spread of healthcare associated infections, which can be transferred by the hands from one environment to multiple surfaces.⁹⁸ Proper hand hygiene also minimizes the spread of bacteria and hands should be washed thoroughly after contact with each patient and contaminated surface.
4. If a surface becomes contaminated since the last cleaning, it should be decontaminated again. Environmental surfaces in operating rooms should receive terminal (deep) cleaning at the end of each surgical or invasive procedure, regardless of the number of times they have been decontaminated that day. Daily terminal cleaning should include cleaning of the anesthesia cart and other environmental surfaces in the operating room or patient care area. Terminal cleaning should also occur in unused operating and patient care rooms to ensure that the environment is decontaminated.
5. Clean high-touch surfaces (e.g., bedrails, countertops) more frequently than low-touch surfaces. Low-touch surfaces such as walls and ceilings should be cleaned weekly or at a minimum on a monthly basis. Additionally, environmental surfaces that may be contaminated by food or beverages (e.g., refrigerators and ice machines) should be included in a regular cleaning schedule.
6. Protective coverings for use on nonanesthetizing equipment or systems and environmental surfaces, such as plastic wrap, aluminum foil, or impervious-backed absorbent paper, shall be

removed and replaced as soon as possible when they become contaminated or at the end of the work shift.

7. All reusable receptacles such as bins and basins shall be inspected and decontaminated regularly and cleaned and decontaminated as soon as possible when soiled with blood or other infectious materials.
8. Do not use alcohol to disinfect large environmental surfaces. Avoid large-surface cleaning methods that produce mists. Facility policy shall determine appropriate EPA-registered cleaning agents used for various cleaning surfaces and types and degrees of soil.
9. In units with high rates of infection, dilute solutions of sodium hypochlorite are effective for routine environmental disinfection.⁹²

Responsible parties should follow manufacturer instructions for appropriate cleaning and usage of EPA-registered disinfectants. Adherence to an infection control program at patient care facilities requires a team effort. As such, CRNAs should stay informed of proper environmental cleaning and disinfection methods as defined by facility policy and national guidelines.

Laundry

OSHA defines contaminated laundry as “laundry which has been soiled with blood or other potentially infectious materials or may contain sharps.”¹²¹ Contaminated laundry shall be handled as little as possible, shall be placed and transported in labeled or color-coded bags or containers at the location where it was used, and shall not be sorted or rinsed in the location of use. When a facility applies Standard Precautions to the handling of all soiled laundry, alternative labeling or color-coding is sufficient if it permits all employees to recognize the container(s) as meeting compliance with Standard Precautions.

Single plastic bags are sufficient for the containment of dry, contaminated laundry. Wet, contaminated laundry shall be double-bagged to avoid potential leakage to the exterior. Employees handling contaminated laundry shall avoid body contact with the contaminated apparel and shall wear gloves and other appropriate personal protective equipment.

While differing opinions exist regarding the safety and effectiveness of laundering scrubs at home, the majority of the literature acknowledges that there is a lack of sufficient evidence to negate support for the practice. Only one study reported a clear linkage between contaminated clothing and infection; however, the laundry was severely contaminated in a commercial facility.¹²² Although several small studies disagree with the practice, they acknowledge inherent limitations such as study size or design. Some literature suggests that home laundering would be satisfactory if certain conditions were met (i.e., healthcare workers received and followed guidance on effective laundering practices). In fact, only one study compared the effectiveness of home laundering of scrubs with commercial laundering and reported no difference in the removal of microbial contamination.¹²² Home laundering is appropriate for uniforms (e.g., scrubs) that have not been contaminated with blood or infectious material.¹²³ Literature shows that when home laundering occurs, a greater number and range of viruses are reduced from clothing when bleach is added to laundry detergent.¹²⁴

Special handling or separate laundering is not required when laundering scrubs at home. Damp laundry should not be left in machines overnight to avoid bacteria growth,¹²⁴ and should be stored in clean, dry conditions to avoid outside contamination. The doors of front-loaded washers should be cleaned prior to and at the conclusion of the wash cycle and then wiped dry to discourage mold or bacteria growth. It is not necessary to disinfect or sterilize residential washers and dryers following the cleaning process when laundering materials in accordance with manufacturer instructions.

A recent study concluded that a direct correlation between the frequency of laundering scrubs and bacterial contamination is nonexistent;¹²⁵ however, scrubs that are changed on a daily basis harbor less resistant bacteria than surgical attire changed less frequently.¹²⁶ Effective laundering methods in conjunction with the use of clean scrubs on a daily basis and good hygiene practices provide less risk for harboring bacteria on uniforms.¹²⁶

Personal bags and jackets belonging to staff that enter the work environment shall be regularly inspected, cleaned and decontaminated when visibly soiled to minimize the spread of HAIs transmitted by fingertips from one environment to multiple surfaces.

Key Recommendations for Laundry

- Handle contaminated laundry as little as possible, place and transport the laundry in labeled or color-coded bags or containers from the location where it was used, and do not sort or rinse the laundry in the location of use. Avoid body contact with soiled items.
- When laundering scrubs and reusable materials at home, use sodium hypochlorite in addition to detergent for the greatest reduction in bacteria and virus survival.^{122, 124}
- Place dry, contaminated laundry in a single biohazardous bag. Wet, contaminated laundry shall be placed in a leak-resistant plastic biohazardous bag.
- Do not leave damp fabrics in machines overnight to avoid bacterial growth.¹²⁴
- Store laundry in clean, dry conditions.

Personal Protective Equipment

OSHA defines personal protective equipment as specialized clothing or equipment worn by an employee for protection against a hazard.¹²¹ Such equipment is impervious to blood and other infectious fluids, and should always be used effectively and whenever there is potential exposure to blood, body fluids or other infectious materials. Hand hygiene should be performed immediately after the removal of any personal protective equipment.

Gowns

Gowns should be available in several different sizes^{38, 121, 127} to encourage practitioner use and to ensure appropriate coverage. Isolation gowns should be removed when wet or soiled and upon leaving patient care areas to prevent contamination of the environment outside the patient's room. Disposable gowns should not be reused.

Gloves

Healthcare professionals should wear gloves when there is contact with potentially contaminated surfaces, blood, body fluids or other infectious agents. Contaminated gloves and gloves with compromised barrier protection should be promptly removed or replaced. Gloves should also be replaced between contact with different patients. Gloves may be used when in contact with high-touch surfaces and should be changed whenever patients share use of portable equipment, computer keyboards and other devices.³⁸ Double-gloving is an effective method for reducing the spread of HAIs when needlestick injuries may occur. Disposable gloves should not be reused.

Masks

Clean masks and other facial protective equipment should be worn as a barrier whenever there is potential for blood or other infectious materials to be spattered, splashed or sprayed. Disposable masks should be removed by the elastic ties or straps and discarded between each patient or when wet or soiled. Immediately following mask removal and disposal, hand hygiene should be performed. Disposable masks should not be reused.

Head and Shoe Coverings

Clean hats, caps, and boot or shoe covers should be worn when it is likely that blood or other infectious matter may spatter, splash or be sprayed onto the hair or shoes. Reusable hats or caps should be laundered regularly and when visibly soiled.

Cover Apparel

Recent studies suggest that white coats may harbor levels of microbial contamination similar to that found on surgical attire. Literature also suggests that white coats do not protect scrubs from becoming contaminated, and may aid in their contamination through improper usage of cover apparel (e.g., not closing lab coats, etc.), infrequent laundering practices, and faulty storage of attire.¹²⁸ Effective laundering methods in conjunction with the use of clean cover apparel on a daily basis and good hygiene practices provide less risk of harboring bacteria.¹²⁶ The AANA recommends that the use of cover apparel be determined at the facility level in accordance with state regulations and consistent with the community standards of practice.

CRNAs with nonintact skin, open lesions and bloodborne diseases should adhere to facility policy and use universal precautions, including donning personal protective equipment and other appropriate measures when initiating patient care, to protect both themselves and their patients.

Key Recommendations for Personal Protective Equipment

- Use appropriate barrier protection when in contact with equipment and surfaces that may be contaminated or frequently touched, and when using devices that are patient-shared or difficult to clean (e.g., computer keyboards).
- Wear personal protective equipment whenever there is a potential for contact with blood or other infectious material. This includes gloves at a minimum and may include a gown, surgical mask, cap, hat, and boot or shoe covers as the situation dictates. All personal protective equipment should be removed prior to leaving the patient care area. Any such protective equipment that becomes contaminated with blood should be promptly removed, and hands washed upon removal.
- Wear clean hats, caps, and boot or shoe covers when it is likely that blood or other infectious matter may spatter, splash or be sprayed onto the hair or shoes. Reusable hats or caps should be laundered regularly and when visibly soiled.

Containment, Labeling, and Disposal of Biohazardous Waste

Biohazardous Waste

Biohazardous waste includes liquid or semi-liquid blood or other potentially infectious materials; contaminated items that would release blood or infectious materials in a liquid or semi-liquid state; items that are caked with dried blood or other infectious materials; contaminated sharps; and pathological and microbiological wastes containing blood or infectious materials.³⁴

OSHA regulations specifically address protection from occupational exposure to bloodborne pathogens. OSHA requires facilities to maintain an accessible, written policy for handling bloodborne pathogen exposure incidences. The regulations primarily address HIV and hepatitis B, but also apply to pathogenic microorganisms present in human blood with the ability to cause disease. In accordance with the OSHA standards, if contaminated breathing circuits, rebreathing bags, airways or accessory items meet the definition of “biohazardous waste,” they should be placed in closable containers that prevent leakage. Containers should also be closed prior to removal from the anesthetizing location to prevent spillage.¹ All containers should be labeled or color-coded.

CRNAs should understand that regulations for labeling and disposing of biohazardous waste are different when materials are transported outside the facility. CRNAs who have responsibilities in this area should consult relevant EPA documents. If outside contamination of the regulated waste container does occur,

the container should be placed in a second container. The second container should conform to the same specifications required of the first container. Disposal of all regulated waste should be in accordance with local, state and federal government regulations. CRNAs should continue to explore environmentally friendly methods for handling, storing and disposing of unregulated noninfectious waste without sacrificing patient safety.

Sharps

The method for disposal of unused drugs may depend on the quantity of product surplus and should occur according to facility policy. Drugs left in ampoules may be discarded within the clinical area of use; however, large amounts of drugs should be returned to the pharmacy for disposal when feasible.¹²⁹ To avoid needlestick injury, contaminated needles should not be bent or recapped. If a needle must be bent, the one-handed technique should be used to prevent injury.³⁸ Sharps and nonsharps regulated medical waste and items with blood on them, including broken glass, needles, syringes, tubing and gauze, should be discarded immediately in closeable sharps containers.¹³⁰ Sharps containers should be puncture-resistant, leak-proof on the sides and bottom, and labeled or color coded.

Key Recommendations for Containment, Labeling, and Disposal of Biohazardous Waste

- Place biohazardous waste in closable, leak-proof containers.
- Dispose of all regulated waste in accordance with local, state and federal government regulations.
- Do not bend or recap contaminated needles.
- Discard sharps immediately in puncture-resistant, leak-proof sharps containers that are labeled or color coded.

Conclusion

This document presents the most recent evidence-based infection prevention recommendations for CRNAs; however, all CRNAs must maintain their familiarity with the state of the science in this area to practice effective infection control during clinical anesthesia care. The breadth and depth of the world of infection control and prevention, as well as the burgeoning science underlying these latest recommendations may change, and CRNAs must recognize the need to alter clinical practice as science dictates. CRNAs are responsible for adhering to any CDC recommendations that are applicable to anesthesia care delivery that may be published after this document. The AANA supports the work of the CDC in fostering patient safety.

Appendices

Appendix 1. Prophylactic Antibiotic Recommendations. From: Webb, A. et al. (2006). Reducing surgical site infections through a multidisciplinary computerized process for preoperative prophylactic antibiotic administration. *Amer J Surg.* 192, p. 663-668.

Local antibiotic recommendations

Service	Procedure	Primary choice	PCN allergy
Cardiac	All	Vancomycin	Vancomycin
Thoracic	All	Cefuroxime	Vancomycin
General	Cholecystectomy (elective)	None	
	Breast	None	
	Breast (high risk)	Cefazolin	Clindamycin
	Hernia	Cefazolin	Vancomycin
	Esophagus/stomach/small intestine/hepatectomy	Cefazolin	Vancomycin
		Cefuroxime	
	Hepatobiliary (acute cholecystitis/indwelling drains)	Cefotetan	Clindamycin/ciprofloxacin
	Appendix/colorectal/anal	Cefotetan	Clindamycin/ciprofloxacin
Gynecology	All	Cefazolin	Clindamycin
			Doxycycline
ENT	Clean	None	
	Clean-contaminated	Cefazolin	Clindamycin
Oral surgery	Clean	None	
	Implants, open fractures, orthonathics	Penicillin	Clindamycin
	Bone graft	Cefazolin	Clindamycin
Orthopedics	Clean, no implants	None	
	Clean, with implants (ORIF/spine/total joints)	Cefazolin	Vancomycin
GU	Low-risk	None	
	High-risk	Ciprofloxacin	Ciprofloxacin
		Ampicillin/gentamicin	
Vascular	All other procedures	Cefazolin	Vancomycin
	DM foot	Ampicillin/sulbactam	Clindamycin/ciprofloxacin
Plastics	Clean	Cefazolin	Clindamycin
			Vancomycin
Podiatry	Clean cases	Cefazolin	Clindamycin
	DM foot	Ampicillin/sulbactam	Clindamycin/ciprofloxacin

PCN = penicillin; DM = diabetic; ORIF = open reduction internal fixation.

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Appendix 2. Decreasing order of resistance of microorganisms to disinfection and sterilization and the level of disinfection or sterilization.

Resistant	Level
Prions (Creutzfeldt-Jakob Disease)	Prion reprocessing
Bacterial spores (<i>Bacillus atrophaeus</i>)	Sterilization
Coccidia (<i>Cryptosporidium</i>)	
Mycobacteria (<i>M. tuberculosis</i> , <i>M. terrae</i>)	High
Nonlipid or small viruses (polio, coxsackie)	Intermediate
Fungi (<i>Aspergillus</i> , <i>Candida</i>)	
Vegetative bacteria (<i>S aureus</i> , <i>P. aeruginosa</i>)	Low
Lipid or medium-sized viruses (HIV, herpes, hepatitis B)	
Susceptible	

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Appendix 3. Factors affecting the efficacy of sterilization.

Factors	Effect
Cleaning	Failure to adequately clean instrument results in higher bioburden, protein load, and salt concentration. These will decrease sterilization efficacy.
Bioburden	The natural bioburden of used surgical devices is 10_0 to 10_3 organisms (primarily vegetative bacteria), which is substantially below the 10_5 - 10_6 spores used with biological indicators.
Pathogen type	Spore-forming organisms are most resistant to sterilization and are the test organisms required for FDA clearance. However, the contaminating microflora on used surgical instruments consists mainly of vegetative bacteria.
Protein	Residual protein decreases efficacy of sterilization. However, cleaning appears to rapidly remove protein load.
Salt	Residual salt decreases efficacy of sterilization more than does protein load. However, cleaning appears to rapidly remove salt load.
Biofilm accumulation	Biofilm accumulation reduces efficacy of sterilization by impairing exposure of the sterilant to the microbial cell.
Lumen length	Increasing lumen length impairs sterilant penetration. May require forced flow through lumen to achieve sterilization.
Lumen diameter	Decreasing lumen diameter impairs sterilant penetration. May require forced flow through lumen to achieve sterilization.
Restricted flow	Sterilant must come into contact with microorganisms. Device designs that prevent or inhibit this contact (e.g., sharp bends, blind lumens) will decrease sterilization efficacy.
Device design and construction	Materials used in construction may affect compatibility with different sterilization processes and affect sterilization efficacy. Design issues (e.g., screws, hinges) will also affect sterilization efficacy.

Used with permission by William Rutala, PhD, MPH. Factor only relevant for reused surgical/medical devices.

Appendix 4. Properties of an ideal disinfectant.

Broad spectrum: should have a wide antimicrobial spectrum

Fast acting: should produce a rapid kill

Not affected by environmental factors: should be active in the presence of organic matter (e.g., blood, sputum, feces) and compatible with soaps, detergents, and other chemicals encountered in use

Nontoxic: should not be harmful to the user or patient

Surface compatibility: should not corrode instruments and metallic surfaces and should not cause the deterioration of cloth, rubber, plastics, and other materials

Residual effect on treated surfaces: should leave an antimicrobial film on the treated surface

Easy to use with clear label directions

Odorless: should have a pleasant odor or no odor to facilitate its routine use

Economical: should not be prohibitively high in cost

Solubility: should be soluble in water

Stability: should be stable in concentrate and use-dilution

Cleaner: should have good cleaning properties

Environmentally friendly: should not damage the environment on disposal

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