

Recommendations for Infection Control for the Practice of Anesthesiology (Third Edition)

Developed by the ASA Committee on Occupational Health Task Force on Infection Control

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Task Force on Infection Control

Robin A Stackhouse, M.D. (Chair)

Richard Beers, M.D.

Daniel Brown, M.D., PhD, FCCM

Morris Brown, M.D.

Elliott Greene, M.D.

Mary Ellen McCann, M.D.

Bonnie M Tompkins, M.D.

I. INTRODUCTION

The importance of infection control risks in healthcare settings is being increasingly recognized with the accumulation of data. It is estimated that 5% to 10% of hospitalized patients in the United States, or approximately 2 million people yearly, acquire 1 or more healthcare-associated infections (HAIs). Infection is a contributory cause in more than 90,000 deaths, and results in excess healthcare costs of \$4.5 to \$5.7 billion per annum. The 4 most prevalent infections, responsible for 80% of the cases of HAIs are: urinary tract infections (accounting for 35% and generally catheter-associated, CAUTI), surgical site infection (SSI; 20% of cases, but accounts for 1/3 of the associated costs), bloodstream infections (15%, majority are intravascular-catheter related), and pneumonia (usually ventilator-associated, 15% of cases, 25% of attributable mortality). Significantly, the etiologic organisms in 70% of these infections are resistant to 1 or more antibiotics.¹ Appropriate anesthesia practices can reduce the incidence of infection related to these and other causes of HAI.

There is increased focus on HAIs from both governmental and non-governmental agencies. In 2008, the Department of Health and Human Services (HHS) established the HHS Action Plan to Prevent Healthcare-Associated Infection that has set targets and metrics for reducing HAIs. Those targets for which anesthesiologists may affect outcome include: methicillin-resistant *Staphylococcus aureus* infections (MRSA), SSIs, central line-associated bloodstream infections (CLABSIs), ventilator-associated pneumonia (VAP), and central line insertion practice compliance (CLIP). The plan is evaluated, revised, and updated regularly. In 2010, improving infection control practices in ambulatory surgery centers and increasing healthcare worker (HCW) vaccination rates were added to the plan. The Centers for Medicare and Medicaid Services (CMS) is reinforcing the impact of the HHS action plan through pay for reporting and pay for performance. The Joint Commission has addressed HAIs by increasingly observing infection control policies and practices during institutional surveys. The Centers for Disease Control and Prevention (CDC) has issued several new and updated guidelines on infection control since the publication of the last edition of the ASA Recommendations for Infection Control including those on: hand hygiene, prevention of CAUTI, disinfection and sterilization, environmental infection control, pneumonia, preventing transmission of infectious agents, intravascular catheter-related precautions, management of multi-drug-resistant organisms, preventing SSI, and vaccination of HCWs.

The authors of this updated (3rd) edition of the ASA's *Recommendations for Infection Control for the Practice of Anesthesiology* have analyzed the current data and national guidelines on infection control. They have drafted a synopsis to inform anesthesia providers of those practices that have been shown to alter the incidence of HAI. In recognition of the infectious risks to both the patient and the anesthesiologist, the document is organized into 2 broad categories: Prevention of Healthcare-Associated Infection in Patients and Prevention of Occupational Transmission of Infection to the Anesthesiologist.

1. Burke JP. Infection control: a problem for patient safety. *N Engl J Med*. 2003;348:651-656.

II. PREVENTION OF HEALTHCARE-ASSOCIATED INFECTION IN PATIENTS

A. Hand Hygiene

i. Recommendations

Hand washing with soap (antimicrobial or non-antimicrobial) should be performed whenever there is visible contamination with blood or body fluids. Alcohol-based hand rubs are recommended for hand hygiene when there is no visible contamination. Spore-forming organisms such as *Clostridium difficile* and *Bacillus anthracis* are poorly inactivated by waterless hand hygiene products and require the physical action of washing and rinsing for removal.^{1,2}

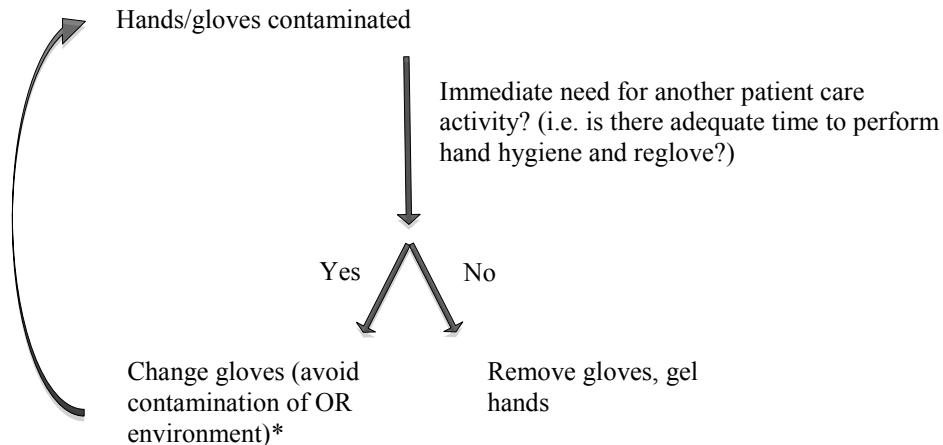
The wearing of artificial nails during direct patient care is discouraged in operating rooms (ORs) or the intensive care unit (ICU). Nail polish may be worn if it is not chipping or peeling. Rings should be removed prior to performing a surgical hand scrub.¹⁻³

Indications for hand hygiene include¹:

- Before and after direct contact with patients.
- Before donning sterile gloves.
- After contact with body fluids, non-intact skin, mucous membranes, wound dressings.
- When hands that have contacted a contaminated body area will subsequently contact a clean site.
- After contact with high-touch environmental surfaces in the vicinity of the patient.
- After removal of gloves.
- Before eating.
- After using the restroom.

Gloves should be worn whenever any contact with blood, body fluids, mucous membranes, non-intact skin, or other potentially infectious material is anticipated. Gloves are not intended for reuse as removal of microorganisms and integrity cannot be ensured.

Figure 1: Hand hygiene algorithm



* Hands are considered contaminated after glove removal. Gloves do not obviate the need for hand hygiene secondary to the incidence of glove failure and self-contamination rates on glove removal.

ii. Rationale

Healthcare-associated infections (HAIs) occur in 5% to 10% of hospitalized patients.⁴ An estimated 1.7 million HAIs occurred in 2002, contributing to 99,000 deaths in the United States.⁵ Hand washing is one of the most effective infection control practices to protect both the patient and healthcare worker (HCW) from colonization and/or infection with microorganisms.⁶ Hands carry a relatively high count (3.9×10^4 to 4.6×10^6 colony forming units (CFUs)/cm²) of resident and transient bacteria. Dermatitis increases bacterial counts and decreases HCW compliance with hand hygiene. Many products include compounds to reduce dermal irritation. Subungual areas have the highest bacterial concentrations and are frequently colonized with coagulase-negative *Staphylococcus*, gram-negative rods, *Corynebacteria*, and yeasts.¹ Alcohol-based hand products decrease the time required for hand hygiene (approximately 30 seconds per use).¹

Recent evidence suggests that there is a direct correlation between contamination of environmental surfaces in the OR and positive cultures on the internal surface of intravenous stopcocks. Patients with positive stopcock cultures had a higher incidence of postoperative infections and mortality. Positive cultures were most common on the adjustable-pressure limiting valve (APL) and anesthetic agent dial.⁷ A follow-up study showed that increasing hand hygiene episodes from approximately 0.15/hour to 7 to 8/hour resulted in a decrease in stopcock contamination from 32.8% to 7.5%, with the only positive cultures occurring secondary to a lack of compliance with hand hygiene or gross contamination of the stopcocks unrelated to hand hygiene.⁸

The OR has unique infection control issues compared with other clinical care areas. OR personnel care for a single patient for prolonged periods. Consequently, microorganisms may be transmitted via 2 mechanisms: contamination of normally sterile sites with a patient's own bacteria, and transmission of bacteria to subsequent patients in the OR by microbes that have contaminated environmental surfaces during a previous case. Although equipment is cleaned between cases in an OR, not all bacteria will be eliminated. Therefore, infection control practices must concentrate on minimizing environmental contamination. Gloves that have been used during patient care should be removed prior to touching equipment. This may be in direct conflict with the requirement to perform hand hygiene upon the removal of gloves. There are times when gloves should be removed before touching environmental surfaces and when there is inadequate time to perform hand hygiene (i.e. immediately after intubation when the anesthetic gases and ventilator need to be adjusted). In these circumstances, hand hygiene should be performed as soon as patient safety allows. Alternatively, double gloves can be worn and the outer glove removed prior to touching environmental surfaces.

The wearing of gloves, however, is not a substitute for hand hygiene as there is a measurable level of glove leakage (either from manufacturing defects or damage during use) and self-contamination during removal. The pre-use glove leakage rate ranges from 1% to 4%, while the post-use rate may be 1.2% to 53%, with surgical gloves performing better than examination gloves. The incidence of positive hand cultures after glove use and removal ranges from 2.2% to 34%.⁹⁻¹²

Table 1:

Antimicrobial Spectrum and Characteristics of Hand-Hygiene Antiseptic Agents*

Group	Gram-positive bacteria	Gram-negative bacteria	Mycobacteria	Fungi	Viruses	Speed of action	Comments
Alcohols	+++	+++	+++	+++	+++	Fast	Optimum concentration 60%–95%; no persistent activity
Chlorhexidine (2% and 4% aqueous)	+++	++	+	+	+++	Intermediate	Persistent activity; rare allergic reactions
Iodine compounds	+++	+++	+++	++	+++	Intermediate	Causes skin burns; usually too irritating for hand hygiene
Iodophors	+++	+++	+	++	++	Intermediate	Less irritating than iodine; acceptance varies
Phenol derivatives	+++	+	+	+	+	Intermediate	Activity neutralized by nonionic surfactants
Tricolsan	+++	++	+	—	+++	Intermediate	Acceptability on hands varies
Quaternary ammonium compounds	+	++	—	—	+	Slow	Used only in combination with alcohols; ecologic concerns

Note: +++ = excellent; ++ = good, but does not include the entire bacterial spectrum; + = fair; — = no activity or not sufficient.
* Hexachlorophene is not included because it is no longer an accepted ingredient of hand disinfectants.

* From Boyce JM, Pittet D; Healthcare Infection Control Practices Advisory Committee; HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. Guideline for hand hygiene in health-care settings. *MMWR Recomm Rep.* 2002;51 (RR-16):1-44.

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12. Muto CA, Siström MG, Strain BA, et al. Glove leakage rates as a function of latex content and brand. *Arch Surg*. 2000;135:982-985.

B. Preventing Contamination of Medications and Fluids

i. Safe Injection Practices: Recommendations

Table 1: Safe Injection Practices¹⁻⁴

<ol style="list-style-type: none">1. Aseptic technique<ol style="list-style-type: none">a. Use aseptic technique to avoid contamination of sterile injection equipment. Category IA2. Syringes, needles, and cannulae*<ol style="list-style-type: none">a. Do not administer medications from a syringe to multiple patients, even if the needle or cannula on the syringe is changed.b. Needles, cannulae, and syringes are sterile, single-use items.<ol style="list-style-type: none">i. Do not reuse for another patient or to reaccess a medication or solution. Category IA3. Single-dose vials (SDVs)<ol style="list-style-type: none">a. Use single-dose vials for parenteral medications whenever possible rather than a multidose vials.b. Do not administer medications from SDVs or ampules to multiple patients or combine leftover contents for later use. Category IA4. Multi-dose vials (MDVs)<ol style="list-style-type: none">a. If MDVs must be used<ol style="list-style-type: none">i. Both the needle or cannula and syringe used to access the MDV must be sterile.b. Do not keep MDVs <i>for use on multiple</i> patients in the immediate patient treatment area (italics added as per clarification by CDC to ASA: see "All medications and solutions..." at end of Rationale section) and:<ol style="list-style-type: none">i. Store in accordance with the manufacturer's recommendations.ii. Discard if sterility is compromised or questionable. Category IA5. Fluid infusion and administration sets (i.e., intravenous bags, tubing, and connectors)<ol style="list-style-type: none">a. Use for 1 patient only and dispose appropriately after use.b. Consider a syringe or needle/cannula contaminated once it has been used to enter or connect to a patient's intravenous infusion bag or administration set.c. Do not use bags or bottles of intravenous solution as a common source of supply for multiple patients. Category IB
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The CDC's *Safe Injection Practices* recommendations are all category IA or IB.

Category IA: Strongly recommended for implementation and strongly supported by well-designed, experimental, clinical, or epidemiologic studies.

Category IB: Strongly recommended for implementation and supported by some experimental, clinical, or epidemiologic studies and a strong theoretical rationale.

* Recommendation (2) was adopted as an official recommendation of ASA by the House of Delegates on October 20, 2010.

Table 2: Medication and Fluid Use in the Immediate Patient Treatment Area¹⁻⁷

- Follow *Safe Injection Practices* see Table 1.
- Use appropriate aseptic technique and hand hygiene.
- All medications and fluids are single-patient-use only (including SDVs, MDVs, ampules, syringes, bottles and bags, and controlled substances from pharmacy).
- Use aseptic technique, including use of an alcohol swab or appropriate disinfectant, to cleanse the vial's rubber septum before entering.
- Cleanse the neck of glass ampules with an alcohol swab and let dry before opening.
- When any medication vial (or solution) is accessed, both the syringe AND the needle/cannula must be sterile.
- A “double layer” of safety precautions is needed: (1) use a sterile syringe and needle/cannula each time any medication or solution is accessed, and (2) do not use a medication or solution for multiple patients in the “Immediate Patient Treatment Area”. The CDC specifically states “Healthcare providers should never reuse a needle or syringe either from one patient to another or to withdraw medicine from a vial.”⁴ Syringes, needles, and cannulae are sterile single-use items and must not be reused to access any medication or solution.
- If a medication (or other solution) is not available in the single-dose form and a MDV must be used (e.g., neostigmine, succinylcholine) discard the MDV after single patient use.
- Syringes should be capped when not in use.
- Discard all used and/or opened medication/fluid containers (e.g., cap off, bag entered) no later than the end of the patient’s anesthetic. Exception: bag/bottle in use with administration tubing connected to patient’s vascular access.
- Opened single-dose ampules must be immediately discarded and not be stored for any time period.
- Discard used needles/syringes intact in a nearby sharps container after use or, at the latest, at the end of the patient’s anesthetic.
- Store unused syringes, needles, and related items in a clean area to avoid cross-contamination from used items.
- Store medications and solutions in accordance with the manufacturer’s recommendations and discard if sterility is compromised.

CDC = Centers for Disease Control and Prevention; MDV = multi-dose vial; SDV = single-dose vial.

ii. Rationale

In the past 15 years, numerous publications have described iatrogenic hepatitis C virus (HCV) transmission unrelated to transfused blood products or transplantation procedures. Nearly all were due to unsafe therapeutic injection practices related to MDVs and infusion bags contaminated by reinsertion of used needles/syringes, use of a single needle/syringe for intravenous (IV) medication administration to multiple patients or use of a contaminated finger-stick glucose measurement device on multiple patients.⁸ In some situations, syringes or needles used on HCV-

infected persons were directly reused on other persons. In others, syringes or needles used on HCV-infected persons were reused to draw medication from a vial or infusion bag; the vial or bag contents were subsequently drawn up and administered to multiple persons.⁹⁻¹²

Between June 1998 and June 2008, a total of 33 outbreaks of patient-to-patient transmission of hepatitis B virus (HBV) or HCV due to breaches in infection control by health care personnel were reported in the United States. More than 60,000 patients were potentially at risk and 448 acquired HBV or HCV infection. These numbers are likely a gross underestimation as the data only reflect recognized outbreaks of ≥ 2 persons that could be linked to a specific health care facility.² Disease transmission in most cases was attributed to health care workers' unsafe injection practices during the preparation and administration of parenteral medications and lapses in aseptic technique, primarily due to reuse of syringes and contamination of medications or flush solutions. Delivery of anesthesia care was involved in 7 of the 33 outbreaks, with over 55,000 patients identified as at risk, of which, 144 acquired HBV or HCV infection. In 2002, the single largest outbreak resulted in HBV and/or HCV infections in 102 patients due to reuse of needles and syringes to inject midazolam, fentanyl, and propofol into the IV tubing of multiple patients; 908 patients required notification of potential risk.^{2,3} In 2008, the reuse of syringes on multiple patients and use of propofol single-dose vials (SDVs) for multiple patients resulted in 6 acute HCV infections, with 40,000 patients requiring notification of potential risk; a new needle with a used syringe was used to draw more medication from the vials.¹¹ Contaminated blood glucose monitoring equipment was involved in 15 non-anesthesia incidents. While these 33 outbreaks occurred in non-hospital settings, a smaller number of outbreaks in hospital settings have also been documented.² No cases of health care-associated human immunodeficiency virus infection have been identified since the 1990s.²

After investigating 4 of the largest outbreaks, the Centers for Disease Control and Prevention (CDC) published recommendations for *Safe Injection Practices*, adopted by its Healthcare Infection Control Practices Advisory Committee (HICPAC) in 2007 as part of "Standard Precautions," to define and reinforce principles of injection safety and aseptic technique.³ These recommendations were formulated to prevent or reduce the possibility of contamination of injection or infusion supplies and subsequent transmission of disease to patients.^{2,4} Aseptic technique for injection safety refers to handling, preparation, and storage of medications, solutions, and injection equipment to prevent microbial contamination. This applies to all supplies used for injections and infusions including medication vials, ampules, syringes, needles, cannulae, fluid containers, and tubing.² The CDC states "These and other outbreaks of viral hepatitis could have been prevented by adherence to basic principles of aseptic technique for the preparation and administration of parenteral medications. These include the use of a sterile, single-use, disposable needle and syringe for each injection given and prevention of contamination of injection equipment and medication."³ The CDC recently published recommendations for managing serious infection control breaches (e.g., reuse of injection equipment) that include patient notification and testing for HBV, HCV and HIV.¹³

The CDC identified problematic practices relevant to anesthesia include: (1) using the same needle/cannula and/or syringe to administer IV medication to multiple patients; (2) inserting a used needle/cannula and/or syringe into a medication vial or solution container resulting in

contamination of the contents and subsequent reuse for other patients; and (3) using SDVs as equivalent to MDVs in which the vial is entered on multiple occasions for different patients.^{2,5}

The practice of changing a needle (or cannula) and reusing the syringe is DANGEROUS. Studies from the 1980s established that (1) removing a needle from a syringe produces a siphoning effect that aspirates needle contents into the syringe, and (2) a needle containing viruses or bacteria will contaminate the syringe even if the needle is flushed prior to removing it from the syringe.⁶ It is NEVER acceptable to reuse needles, cannulae, syringes, medications or other solutions, fluid infusions (e.g., bags, bottles), administration sets, or tubing for another patient (see CDC recommendations # 2 and 5 in Table 1).

Studies in the mid-1990s indicated that 20% to 39% of anesthesia personnel reused syringes on multiple patients¹⁴; in 2002, this rate decreased to 1% to 3%.¹⁵ Despite ongoing educational efforts, in 2008, limited data indicate that up to 27% of clinicians may be reusing propofol infusion syringes while changing only the microbore tubing between patients¹⁶; syringe reuse in this situation places patients at risk because the syringe contents and/or plunger could be contaminated by handling, fluid splattering, or retrograde flow during or between uses. Intravenous tubing and valves are not sufficient to prevent backflow and contamination of injection devices. Blood has a higher specific gravity than IV solutions so passive backflow against forward flowing fluid is possible. Lack of visible blood in tubing or injection equipment does NOT eliminate the possibility of microbial contamination. Blood contamination was found in up to 3.3% of tubing injection sites; in only 33% of these instances was the contamination visible to the naked eye.¹⁴

Refilling of a syringe intended for use on the same patient presents the following infectious risks: (1) multiple injection and withdrawal cycles increase the chances of syringe contamination,⁶ (2) there is a risk that the syringe could be mistakenly considered unused and then be reused on a subsequent patient, (3) the accessed vial is also now contaminated and any inadvertent subsequent reuse for another patient can transmit infectious agents to that patient, and (4) if the healthcare worker suffers a needlestick injury during or after refilling a syringe, the needlestick source is now a potentially contaminated needle/syringe. It should also be noted that disposable syringes are labeled “single-use only” by the manufacturer.

iii. CDC Summary/Clarification of Injection Safety Issues

The application of some of the recent CDC recommendations (Tables 1 and 2) to the practice of anesthesiology was uncertain. To clarify these issues, discussions were held with representatives of the CDC and the New York State Department of Health (NYSDOH) between November 2008 and February 2009. The following summarizes the CDC's published recommendations (Table 1)^{3,4} and clarifications pertinent to anesthesiologists.^{5,7}

1. Definition of "Immediate Patient Treatment Area"

For the practice of anesthesiology, the CDC defines the "Immediate Patient Treatment Area" (Table 2) to include, at minimum, surgery/procedure rooms where anesthesia is administered and any anesthesia medication carts used in or for those rooms. The CDC indicates that anesthesia drug carts "represent mobile surfaces that can come into contact with body fluids or other soiled materials. The intended effect of the recommendation 'Do not keep MDVs in the Immediate Patient Treatment Area' is to ensure geographic separation of activities; thus, a cart would not be an appropriate place for MDV aliquotting for multiple patients, regardless of where it is [located] at the time."⁵

2. *"Do not administer medications [or other solutions] from single-dose vials or ampules to multiple patients or combine leftover contents for later use."*

Single-dose containers (SDVs, bags, bottles) are specifically for single patient use and must not be used as a common supply source for multiple patients even if a NEW needle/cannula and syringe are used. Potential hazards from reuse include contamination and microbial transmission to other patients.

3. *A "double layer" of safety precautions is needed: (1) use a sterile syringe and needle/cannula each time any medication or solution is accessed, and (2) do not use a medication or solution for multiple patients in the "Immediate Patient Treatment Area."*

The CDC specifically states "Healthcare providers should never reuse a needle or syringe either from one patient to another or to withdraw medicine from a vial."⁴ *Syringes, needles, and cannulae are sterile single-use items and must not be reused to access any medication or solution.* Following basic infection control practices, 2 techniques are acceptable to the CDC. One is to draw the entire contents of a vial (SDV or MDV) into a sterile syringe and then use the same syringe for sequential doses in the SAME patient. Alternatively, sequential doses may be obtained for the same patient from the same vial using a NEW needle/cannula/syringe each time the vial is accessed. The vial should then be discarded when empty or no later than the end of the case. Repeated use of the same needle/cannula/syringe to obtain doses of any medication or solution for a patient followed by using that medication or solution for other patients is a DANGEROUS practice, as the medication or solution may be contaminated and a source of microbial transmission. Furthermore, if a medication or solution is reused for multiple patients the clinician may not be aware of the access technique previously used.

While the original CDC recommendations³ from June 2007 state, "Do not reuse [needles, cannulae, and syringes] for another patient nor to reaccess a medication or solution that might be used for a subsequent patient," the CDC subsequently clarified this.¹⁷ "To provide a simpler message and a margin of safety consistent with the general principles underlying the entire set of recommended practices, we [CDC] have restated this more recently as 'Do not enter a vial with a used syringe or needle'."⁴ The CDC further states: "The language [from June 2007] is imperfect in that it seems to invite a break in aseptic technique. In addition, unless the vial is emptied or discarded at the time medication is withdrawn, one cannot guarantee that the vial will only be used for that patient."¹⁷ Therefore Table 1 reflects the most recent CDC Recommendations.^{4,17}

4. *All medications and other solutions (including SDVs, MDVs) used at the patient's bedside or "Immediate Patient Treatment Area" must be for single-patient-use only and be discarded at or before the end of the case (Tables 1 and 2).*

To reduce the potential for disease transmission, the CDC recommends that all medications and fluids used in these areas should be supplied, when possible, with single-patient-use only containers (e.g., SDV). If a MDV must be used in the immediate patient treatment area (e.g., medications such as neostigmine and succinylcholine are not supplied in SDVs), discard the MDV after using it for one patient. It is recommended that MDVs for use on multiple patients not be stored in immediate patient treatment areas and also be discarded if sterility is compromised or questionable. While MDVs, unlike SDVs, contain bacteriostatic and/or bactericidal agents, it is incorrect to assume these agents are sufficient to prevent transmission of infection after extrinsic contamination nor do they have any antiviral action. Only under controlled conditions in non-patient care areas (e.g., in a satellite pharmacy) may medications (or other solutions) from multi-dose containers be separated into aliquots for use in multiple patients.

iv. Additional Rationale

Postsurgical infections with fever, infection, sepsis, other life-threatening illness and/or death have been reported after extrinsic contamination of propofol¹⁸⁻²² (also see "Expiration Time for Medications").²³⁻²⁵ The postoperative infections in the early cases were attributed to lapses in aseptic technique with propofol. Risk factors include: "batch" preparation of syringes for use throughout the day, reuse of syringes or infusions for multiple patients, use of syringes prepared up to 24 hours in advance, transfer of prepared syringes between ORs or facilities, sometimes failing to wear gloves during insertion of intravenous catheters or when contacting mucous membranes or in preparation and use of propofol, and failure to disinfect the rubber stoppers of propofol vials. In addition, 50-mL and 100-mL single-use single-patient vials were used as multi-dose and multi-patient vials. At that time the formulation did not contain bacteriostatic agents or preservatives.

Drugs such as propofol that are formulated in a lipid emulsion support bacterial growth that increases rapidly starting 6 hours after inoculation.²⁴⁻²⁶ Propofol formulations in the United States now have a bacteriostatic agent—sodium metabisulfite, benzyl alcohol, or disodium edetate—which is added to the solution to slow the rate of growth of microorganisms in the event of accidental extrinsic contamination; however, propofol can still support the growth of microorganisms because it is not an antimicrobially preserved product.^{24,25}

On June 15, 2007, the Food and Drug Administration (FDA) issued an alert to inform healthcare professionals about several clusters of patients undergoing procedures in gastrointestinal (GI) suites who experienced chills, fever, and body aches shortly after receiving propofol for sedation or general anesthesia.²³⁻²⁵ The symptoms were similar to cases of infections reported when propofol was first introduced in the United States.¹⁹⁻²¹ The FDA tested multiple vials and propofol but did not identify any vials contaminated with bacteria or endotoxins originating from a manufacturing source.²³⁻²⁵ In June 2007, investigators found single-dose vials used for multiple patients.

Education and training on safe injection practices, aseptic technique, and other principles of infection control with monitoring for adherence are needed in all health care facilities.^{2,3,12} The CDC recommends that all States as well as healthcare institutions and professional groups should consider formal adoption of the CDC recommendations including regular infection control training.² The CDC also recommends office-based surgery facilities obtain nationally recognized accreditation, such as from the Joint Commission.²

v. Infusions

1. Recommendations

All infusions, fluids, administration sets, and containers are single-patient-use. This includes intravenous tubing, pressure transducers and tubing, and other items that come in contact with the vascular system or other sterile body fluids.

Aseptic technique should be used when preparing and using IV infusion and other vascular access administration sets. Entry into the tubing should be minimized.

Stopcocks, injection ports, and other portals of access to sterile fluids should be maintained with sterile and aseptic techniques. Stopcocks should be kept free of blood and covered by a sterile cap or syringe when not in use. IV injection ports should be cleaned with alcohol prior to entry.

Before use check all containers of parenteral fluids for visible turbidity, leaks, cracks, particulate matter, and the manufacturer's expiration date.

Multi-day infusions should be purchased as pre-manufactured sterile products or should be compounded in accordance with United States Pharmacopeia (USP) 797 guidelines.

Decrease infectious risk by minimizing the number of entries in the sterile infusion sets used in continuous regional anesthetic techniques, including top-ups or bag changes.

2. Rationale

Fluids, internal surfaces of infusion tubing, and any devices in contact with the vascular system or other sterile body areas must be maintained sterile. Stopcocks and other injection ports (used for medication injection, fluid infusion, and collection of blood samples) represent a potential entry site for microorganisms into vascular catheters and fluids.²⁷ Bloodborne infections may be transmitted to other patients if an infusion is used on multiple patients. Blood backup (gross or microscopic), and blood withdrawal or transfusion will contaminate the infusion administration set. A one-way valve in the administration tubing does not prevent retrograde blood flow from entering the tubing via the IV catheter.¹⁴ Product sterility and absence of blood contamination cannot be guaranteed by visual inspection.

Infusions may be contaminated by failure to use aseptic/sterile techniques, by droplet or contact transmission of microorganisms during breaks in infusion system continuity, or by direct transmission during use on a patient. Bacterial and fungal infections with use of propofol have been associated with extrinsically contaminated infusions as well as infusions that were used on multiple patients.²⁸ Also see sections “Syringes, Needles, Single-dose Vials, Multi-dose Vials, Ampules, other Fluids” and “Expiration Time for Medications.”

The USP is a non-governmental organization that sets standards, recognized worldwide, for ensuring the quality, safety, and proper use of medications.²⁹ The USP standards are enforceable by state boards of pharmacy, state boards of health, the Federal Food and Drug Administration and by the Joint Commission.

In 2004, after 3 decades of case reports of infections in patients from contaminated compounded medications and poor compliance with voluntary guidelines, the USP published Chapter 797: “Pharmaceutical Compounding, Sterile Preparation” to improve all practices for compounding sterile preparations. The guidelines’ purpose is to “prevent harm, including death, to patients that could result from the following: (1) microbial contamination, (2) excessive bacterial endotoxins, (3) variability in the intended strength of correct ingredients, (4) unintended chemical and physical contaminants, and (5) incorrect types and qualities of ingredients in CSPs [Compounded Sterile Preparations].”²⁹ The Joint Commission now uses USP Chapter 797 when surveying hospitals and has expected full compliance since January 2008.

Cases of continuous infusate contamination in regional anesthesia have been rare. However, a recent case led to devastating infectious complications and has highlighted concern in view of the recently increasing practice of discharging postoperative patients with local anesthetic infusions administered via perineural catheters using portable pumps.^{28,30,31}

vi. Expiration Time for Medications

1. Recommendations

Medications should be drawn into a syringe as close as possible to the time of administration.

USP 797 states that solutions/medications not for immediate use (within 1 hour) require preparation in an ISO 5 class environment.²⁸ However, this environment is not obtainable by anesthesia practitioners in the OR suite. The implications of USP 797 for the practice of anesthesia are unresolved.

Label preparations with medication name, concentration, and time of preparation or expiration date.

Opened single-dose ampules must be immediately discarded and not be stored for any period.

Lipid emulsions such as propofol should be prepared for use just prior to administration. Use strict aseptic technique during handling including hand hygiene before use. The vial’s rubber stopper should be disinfected with 70% isopropyl alcohol before accessing. A syringe containing propofol should be labeled with the date and time the vial was opened.

For anesthesia purposes, any unused portion of propofol must be discarded at the end of the procedure or within 6 hours after the vial was opened, whichever occurs sooner, according to the manufacturer. The implications of USP 797 for this are unresolved at this time. The IV line should be flushed every 6 hours or sooner to remove any residual propofol.

For ICU sedation, when propofol is administered as an infusion from a bottle (e.g., 50 or 100 mL) the tubing and any unused portions must be discarded within 12 hours after the vial has been entered.

2. Rationale

Several factors affect the stability and sterility of medications. These include the particular drug, the presence of a bacteriostatic or preservative agent, the solution used for admixture (if any), potential for contamination during preparation and use, attention to aseptic technique, storage conditions, and the chemical stability of the compound.

Opened single-dose ampules clearly are uncapped open containers and therefore cannot be stored safely and must be immediately discarded after contents are obtained.^{28,29}

Previous editions of these recommendations (1992 and 1998) have included statements to discard syringes with non-lipid contents at latest at 24 hours; however, if recent USP 797 standards are applied to the practice of anesthesia this would change to 1 hour. According to the USP 797 “opened or needle-punctured single-dose containers, such as bags, bottles, syringes, and vials of sterile products and CSPs [compounded sterile products, i.e., medications added to a solution] shall be used within 1 hour if opened in worse than ISO class 5 (maximum of 3,520 particles up to 0.5 microns in size per cubic meter of air) air quality, and any remaining contents must be discarded.”^{28,29} Achieving ISO 5 air quality includes use of a sterile hood with laminar air flow, which is not obtainable in the OR by anesthesia practitioners. In view of the difficulty of achieving USP 797 requirements for the practice of anesthesia, where sequential doses are routinely needed for lengthy procedures and emergency drugs need to be immediately available, as of January 2011 recommendations for the expiration time of medications are unresolved.

For propofol, also see sections “Safe Injection Practices” and “Infusions.”

vii. Non-injectable Items

1. Recommendations

Non-injectable items such as ointments, lubricants, gels, and medication sprays supplied in unit-dose containers for single-patient use are preferable to multi-dose containers used for multiple patients.

Non-injectable items that are packaged in multi-dose containers should be administered in such a manner as to avoid cross-contamination and should be restricted to single-patient use.

Any non-injectable drug should be discarded if visible or suspected contamination has occurred.

2. Rationale

Proper technique is required to avoid contamination of multi-dose containers to prevent potential cross-infection among patients. Product contamination can occur by airborne transmission or direct contact with blood, any body fluid or tissue, or any item soiled with these.³²

Many non-injectable items are packaged in unit-dose form. The unit-dose container is preferable if available because contamination of a larger multi-dose container or contents may not be visible.

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C. Prevention of Surgical Site Infections

It has been estimated that surgical site infections (SSIs) occur in 2% to 5% of all patients who undergo surgery in the United States, resulting in 800,000 to 2 million surgical site infections annually. In addition, SSIs account for 38% of nosocomial infections in surgical patients and result in increased mortality, intensive care unit (ICU) admission, length of hospital stay, cost, and hospital readmission.¹⁻⁴ The Centers for Disease Control and Prevention (CDC) published recommendations concerning the reduction of SSI risk based on scientific data, theoretical rationale, and applicability. The following are recommendations viewed as effective by the Healthcare Infection Control Practices Advisory Committee (HICPAC) of the CDC and by experts in the fields of surgery, infectious disease, and infection control.

i. Preoperative Considerations

1. Hair removal

- Recommendation: Do not remove hair preoperatively unless the hair at or around the incision site will interfere with the operation. If necessary, remove immediately before the operation, preferably with electric clippers.
- Rationale: Preoperative shaving of the surgical site the night before an operation is associated with a higher SSI risk than either the use of depilatory agents or no hair removal.⁵⁻⁷ The increased SSI risk associated with shaving is thought to be due to microscopic cuts in the skin which serve as foci for bacterial growth. Clipping hair immediately before the operation decreases SSI rates.⁸⁻¹⁰

2. Glucose control

- Recommendation: Consider control serum blood glucose levels preoperatively in all diabetic patients and avoid perioperative hyperglycemia, to an extent that would not place the patient at risk of hypoglycemia.
- Rationale: While the contribution of diabetes to SSI risk is controversial, data suggest that a significant relationship exists between increasing levels of hemoglobin (Hg) A1c and SSI rates.¹¹ In addition, hyperglycemia (>200 mg/dL) has been associated with increased SSI risk in the immediate postoperative period.^{12,13}

3. Nicotine use

- Recommendation: Encourage tobacco cessation for at least 30 days before elective operation.
- Rationale: Smoking has been implicated as an independent SSI risk factor.^{14,15}

4. Transfusion

- Recommendation: Do not withhold necessary blood products from surgical patients as a means to prevent SSI.
- Rationale: Because of methodological problems identified in previously reported studies,¹⁶ there currently is no scientific basis to support withholding indicated blood products from surgical patients as a means to reduce SSI risk.

5. Antiseptic shower

- Recommendation: Require patients to shower with an antiseptic agent on the night prior to surgery.
- Rationale: A preoperative bath or shower with povidone-iodine or triclocarban-medicated soap or chlorhexidine gluconate-containing products decrease skin microbial colony counts.^{17,18}

6. Antimicrobial prophylaxis

- Recommendation
 - Administer a prophylactic antimicrobial agent only when indicated and select it based on its efficacy against the most common pathogens causing SSI for a specific operation and published recommendations.
 - Administer the initial dose of prophylactic antimicrobial agent by the intravenous route timed such that a bactericidal concentration of the drug is present in the serum and tissues at the time of incision. Maintain therapeutic levels of the drug in serum and tissues throughout the operation.
 - Continue antimicrobial therapy until, at most, a few hours after the incision is closed in the operating room (OR).
 - Use enemas and cathartic agents in addition to intravenous antimicrobial agent prophylaxis before elective colorectal operations (e.g., elective colon resection, low anterior resection of the rectum, and abdominal-perineal resection of the rectum) to mechanically prepare the colon. Administer non-absorbable oral antimicrobial agents in divided doses on the day before the operation.
 - Antimicrobial prophylaxis should be administered within 60 minutes prior to incision for cesarean delivery.
- Rationale
 - Antimicrobial prophylaxis should be used for those operations or classes of operations in which its use has been shown to reduce SSIs based on evidence from clinical trials or for those operations after which incisional/space SSI would be catastrophic.^{19,20} An antimicrobial agent should be selected which is safe, inexpensive, and bactericidal with an in vitro spectrum that covers the most probable contaminants for the operation.^{21,22}
 - Time the intravenous infusion of the antimicrobial agent to achieve a bactericidal concentration of the drug in serum and tissues by the time of initial skin incision.²³
 - Maintain serum and tissue concentration of the antimicrobial agent due to the presence of clotted blood in all surgical wounds which may allow fibrin-enmeshed bacteria to be resistant to phagocytosis.^{21,24}

- Preparation of the colon with enemas and cathartic agents followed by the oral administration of non-absorbable antimicrobial agents empties the bowel of its contents and reduces the levels of live microorganisms.^{25,26}
- Administration of an antimicrobial agent prior to incision for cesarean delivery has been shown to significantly reduce the incidence of postoperative maternal infectious complications without increasing infection related neonatal morbidity.²⁷

Intraoperative Considerations

1. Operating Room Ventilation

- Recommendations: Maintain positive-pressure ventilation in the operating room with respect to the corridors and adjacent areas as well as a minimum of 15 air changes per hour in the OR, of which at least 3 should be fresh air. Filter both recirculated and fresh air through appropriate filters. Introduce all air at the ceiling, and exhaust near the floor. No need to use UV radiation in the OR to prevent SSI. Keep OR doors closed except as needed for passage of equipment, personnel, and the patient.
- Rationale: Positive pressure prevents airflow from less clean areas into more clean areas.²⁸ The microbial level in OR air is directly proportional to the number of people moving about in the room.²⁹ All ventilation systems in hospitals should have 2 filter beds in series.³⁰

2. Cleaning

- Recommendations: Use an Environmental Protection Agency (EPA)–approved hospital disinfectant to clean affected areas before the next operation when visible soiling or contamination with blood or other body fluids of surfaces or equipment occurs during an operation. No need to perform special cleaning or closing of ORs after contaminated or dirty operations. No need to use tacky mats at the entrance to the OR for infection control.
- Rationale: Environmental surfaces in U.S. operating rooms (e.g., tables, floors, walls, lights) are rarely implicated as the source of pathogens in SSIs, but cleaning soiled or contaminated surfaces with an EPA-approved hospital disinfectant is important after each operation.³⁰⁻³² Tacky mats have not been shown to reduce the number of organisms on shoes or stretcher wheels, nor reduce SSI risk.^{28,33}

3. Surgical attire

- Recommendations: Wear a surgical mask in surgical environments when open sterile items and equipment are present and a cap or hood that fully covers hair on the head and face throughout the operation. No need to wear shoe covers to prevent SSI. Change scrubs that are visibly soiled, contaminated, and/or penetrated by blood or other potentially infectious material.
- Rationale: The use of barrier precautions is important to minimize a patient’s exposure to the skin, mucous membranes, or hair of surgical team members as well as to protect surgical team members from exposure to blood and bloodborne pathogens.³⁴⁻³⁶ Shoe covers do not decrease bacteria counts on the OR floor or reduce SSI risk.³⁷ Occupational Health and Safety Administration (OSHA) regulations require that garments penetrated by blood or other potentially infectious material be removed immediately or as soon as feasible.³²

4. Asepsis and surgical technique

- Recommendation: Adhere to principles of asepsis when placing intravascular devices and spinal or epidural catheters, or when dispensing and administering intravenous drugs.
- Rationale: Rigorous adherence to aseptic technique is the foundation of SSI prevention. Anesthesia personnel have been implicated as the source of the pathogen in SSIs. Lack of strict adherence to the principles of asepsis including reuse syringes, contaminated infusion pumps, and contaminated intravenous anesthetic have been associated with postoperative infections including SSIs.^{38,39}

5. Normothermia

- Recommendation: Maintain patient normothermia.
- Rationale: Hypothermia (core temperature <36°C) has been associated with an increased SSI risk.^{40,41} Mild hypothermia seems to increase SSI risk by causing vasoconstriction, decreased oxygen delivery to the wound space, and impaired phagocytic leukocyte function.^{42,43}

iii. Postoperative Considerations

1. Postoperative Incision Care

- Recommendation: Wash hands before and after dressing changes and any contact with the surgical site.
- Rationale: Strict adherence to hand-washing and aseptic technique remains the cornerstone of infection prevention. Failure of hospital personnel to use appropriate hand-washing techniques is well-documented and has been the cause of numerous infections.⁴⁴

2. Surveillance

- Recommendation: Use strict CDC definitions of SSI without modification for inpatient and outpatients.⁴⁵
- Rationale: Surveillance methods require common definitions for inpatients and outpatients.⁴⁶

iv. Unresolved issues

- No recommendation to enhance nutritional support for surgical patients solely as a means to prevent SSI.
- No recommendation to preoperatively apply mupirocin to nares to prevent SSI.
- No recommendations on how or where to launder scrub suits, on restricting use of scrub suits to the operating suite, or for covering scrub suits when out of the operating suite.
- No recommendation to cover an incision closed primarily beyond 48 hours, or on the appropriate time to shower or bathe with an uncovered incision.

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D. Prevention of Intravascular Catheter-Related Infections

Intravascular catheters are an essential part of patient care for anesthesiologists. Although these catheters provide necessary vascular access, they put patients at risk for local and systemic infectious complications.¹ Catheter-related infections are associated with increased morbidity and mortality, prolonged hospitalization, and increased medical costs.^{2,3} The following recommendations to prevent catheter-related infections are based on guidelines published by the Centers for Disease Control (CDC).

i. General Considerations

1. Hand hygiene

- Recommendations: Wash hands with conventional antiseptic-containing soap and water or with waterless alcohol-based gels or foams before and after palpating, inserting, replacing, or dressing any intravascular device. Wash hands even when gloves were worn.
- Rationale: Good hand hygiene along with proper aseptic technique during catheter manipulation provides protection against infection. Numerous epidemics of device-associated bacteremia have been linked to hospital personnel transmitting the epidemic strain from their hands.⁴⁻⁶

2. Aseptic technique

- Recommendations:
 - Use gloves when inserting an intravascular catheter as required by the Occupational Safety and Health Administration (OSHA) Bloodborne Pathogens Standard.
 - Clean gloves are acceptable in conjunction with a “no touch technique” for insertion of peripheral intravenous (IV) catheters. Sterile gloves should be worn for insertion of arterial and central catheters.⁷
- Rationale
 - A new pair of disposable non-sterile gloves can be used for inserting peripheral catheters if the insertion site is not palpated after the application of antiseptic.⁸
 - Sterile gloves must be worn for the insertion of arterial and central catheters.⁷
 - Maximal sterile barrier precautions during insertion of arterial and central venous catheters (CVC) substantially reduces the incidence of catheter-related bloodstream infections (CRBSI) compared with standard precautions.^{9,10} The CDC recommends the use of a small sterile fenestrated drape for arterial line placement.¹⁰

3. Catheter site care

- Recommendations
 - Disinfect clean skin with an appropriate antiseptic before catheter insertion, insertion and dressing changes, preferably with a 2% chlorhexidine-based preparation; however, tincture of iodine, an iodofor, or 70% alcohol can be used.

- Do not apply acetone to the skin before inserting catheters or during dressing changes.¹¹
- Rationale
 - The use of skin cleansing/asepsis with 2% chlorhexidine gluconate has been shown to reduce the incidence of catheter-related infections.¹²
 - The use of acetone has not been shown to reduce infectious complications.¹¹

4. Dressing regimens

- Recommendations
 - Cover catheter site with sterile gauze or sterile, transparent, semipermeable dressing.
 - Do not routinely apply topical antimicrobial ointment to the insertion site (except with dialysis catheters).¹³
- Rationale
 - Transparent dressings that permit moisture to escape from beneath the dressing may be associated with lower rates of skin colonization and catheter-related infection. Comparable infection rates have been documented when a sterile gauze dressing is used.¹⁴
 - Antibiotic ointment or creams may increase antimicrobial resistance and significantly increase catheter colonization with fungal species.¹⁵

5. Replacement of administration sets

- Recommendations
 - Replace administration sets (the area from the spike of tubing entering the fluid container to the hub of the vascular access device) no more frequently than at 72-hour intervals unless catheter-related infection is suspected.
 - Replace tubing used to administer blood products or lipid emulsions within 24 hours of initiating the infusion.
- Rationale: There is no reduction in infection rates if administration sets are routinely changed more frequently than 72 hours.¹⁶ Infusion of fluids that enhance microbial growth (e.g., blood and propofol) indicate more frequent change of administration sets as these fluids have been identified as independent risk factors for CRBSI.^{17,18}

ii. Other Considerations

- *Recommendations*
 - Clean injection ports before accessing the system.
 - Do not routinely use in-line filters.
 - Do not routinely administer antimicrobial prophylaxis.
- *Rationale*
 - Use of 70% alcohol or an iodofor before accessing the system reduces microbial contamination of vascular catheter hubs.¹⁹

- While in-line filters have been shown to reduce infusion related phlebitis, no data support the routine use of in-line filters to reduce catheter-related and infusion system infections.²⁰
- Antimicrobials do not reduce the incidence of CRBSIs and increase antibiotic resistance.^{21,22}

iii. Central Venous Catheters

[Including peripherally inserted central catheters (PICC) lines, hemodialysis, and pulmonary artery catheters in adults and pediatric patients]

1. Catheter selection

- Recommendations
 - Use a single lumen CVC unless more ports are essential for the management of the patient.
 - Use an antimicrobial or antiseptic-impregnated CVC for catheters anticipated to remain in place >5 days in facilities with an unacceptably high rate of infection after implementation of a comprehensive catheter-related infection reduction program.
- Rationale
 - Multi-lumen catheters are associated with a higher risk of infection than single lumen catheters.²³
 - Once designated/educated personnel insert and maintain catheters, maximal barrier precautions are used, and 2% chlorhexidine is used for skin antiseptics during CVC insertion; the use of antimicrobial or antiseptic-impregnated CVC in adults may further reduce CVC-related infections.²⁴

2. Insertion

- Site recommendations: When choosing the site for insertion of a CVC, the risks and benefits inherent with the subclavian, jugular, and femoral catheterization must be considered in the context of each patient's medical and surgical condition.
- Rationale: A non-tunneled CVC inserted into the subclavian vein carries a lower risk for infection than a catheter inserted via either the jugular vein or femoral vein; the mechanical complications are less common, however, with internal jugular vein insertion than with subclavian insertion.²⁵
- Other recommendations: Promptly remove any intravascular device that is no longer essential.
- Rationale: Removal of unnecessary intravenous catheters will reduce the risk of catheter-related bloodstream infections.

3. Barrier precautions

- Recommendations

- Use sterile techniques including maximal barrier precautions (sterile gown and gloves, a mask and a large sterile drape) for insertion of CVCs (including PICCs) or guidewire exchange. Use these precautions even if the catheter is inserted in the operating room.
- Use a sterile sleeve to cover the catheter with the insertion of a pulmonary artery catheter.
- Rationale
 - The risk of infection of CVCs is associated with the specific barrier protection used during catheter insertion rather than the sterility of the surrounding environment (i.e., ward vs. operating room).^{26,27} Maximal barrier precautions include: a large sterile drape (rather than a small fenestrated drape) that covers the patient's head and body.
 - Use of a protective sleeve with insertion of a pulmonary artery catheter reduces risk of CRBSI.²⁷

4. Catheter replacement

- Recommendations
 - Do not routinely replace non-tunneled CVCs to prevent catheter-related infections.
 - Use a guidewire exchange to replace a malfunctioning, non-tunneled, non-infected CVC or to exchange a pulmonary artery catheter for a CVC.
- Rationale
 - The routine replacements of CVCs do not reduce the rate of catheter colonization or CRBSIs.^{27,28}
 - Catheter insertion over a guidewire is associated with less discomfort and lower rate of mechanical complications than are those inserted at a new site.²⁸

5. Pressure transducers

- Recommendations
 - Use disposable rather than reusable transducer assemblies when possible.
 - Replace transducers at 96-hour intervals.
- Rationale
 - Pressure monitoring systems have been associated with nosocomial bloodstream infections.²⁹ The use of continuous flush devices and disposable transducers has reduced the risk of infection.³⁰

6. Catheter site dressing

- Recommendations
 - Use either sterile gauze or sterile, transparent, semi-permeable dressing to cover the catheter site.
 - Replace catheter site dressing if the dressing becomes damp, loosened, or visibly soiled.
 - Do not use topical antibiotic ointment or creams on insertion site except for dialysis catheters.
- Rationale

- Transparent, semi-permeable polyurethane dressings permit continuous visual inspection of the catheter site and require less frequent changes than do standard gauze and tape dressings. The rate of colonization among catheters dressed with transparent dressings is comparable with that of gauze dressings, and no clinically substantial differences exist in either the incidences of catheter site colonization or phlebitis.
- Topical antibiotic cream and ointments increase the potential to promote fungal infections and antimicrobial resistance.¹⁵

iv. Umbilical Catheters

1. Recommendations

- Cleanse the insertion site with an antiseptic (other than tincture of iodine) prior to insertion.
- Do not use topical antibiotic ointment or creams.
- Add low-dose heparin to fluid infused through umbilical catheters.

2. Rationale

- Tincture of iodine could have effects on the neonatal thyroid and so should be avoided as an antiseptic to reduce infection.^{31,32}
- Topical antibiotic cream and ointments increase the potential to promote fungal infections and antimicrobial resistance.¹⁵
- The addition of low doses of heparin to the infusate reduces the incidence of umbilical catheter thrombosis.³³

v. Unresolved Issues

- No recommendation on the use of chlorhexidine in infants <2 months of age.
- No recommendation for the use of impregnated catheters in children.
- No recommendation for the preferred insertion site to minimize infection for a tunneled CVC.
- No recommendation on the use of chlorhexidine sponge dressings to reduce infection.
- No recommendation for the use of sutureless securement devices.
- No recommendation for treating through an umbilical venous catheter suspected of being infected.

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E. Preventing Ventilator-Associated Pneumonia in the ICU

Ventilator-associated pneumonia (VAP) affects between 9% and 27% of all intubated patients and is associated with high mortality. The following text describes accepted, as well as proposed, measures to minimize development of VAP. The rational institution of these practices depends on the specific care process and setting, though certainly many are applicable to the operating room (OR) practice.

i. General Infection Control Measures

1. Recommendations

Routine hand hygiene practice with compliance audits should be performed. Isolate patients with proven, or at high risk for, antibiotic-resistant infections.

2. Rationale

Infection-control processes top the list of measures advocated for preventing VAP. Staff education and hand hygiene are key activities. There is a significant gap in compliance with hand hygiene, especially in the OR environment. Most facilities have a patient surveillance process that involves placing patients with multi-resistant microbes in isolation to reduce multi-drug-resistant cross-infection. Depending on where a patient is admitted from (e.g., a nursing home or assisted-living facility), many organizations automatically isolate the patient. The idea of isolating certain types of multi-drug-resistant microbes has merit, and surveillance is essential in identifying microbial resistance trends within an institution.

ii. Mechanical Ventilation (MV)

1. Recommendations

Limit the duration of endotracheal intubation and favor non-invasive support if possible. Oral rather than nasal endotracheal intubation access is preferred.

2. Rationale

Endotracheal intubation increases the risk of hospital-acquired pneumonia from 6-fold to 21-fold. Consequently, clinicians should try to minimize invasive MV except in appropriate circumstances. Non-invasive ventilation is an alternative in certain patient populations. Another goal is to limit the duration of MV. The duration of endotracheal intubation has been shown to be minimized by using daily spontaneous breathing trials and/or constantly evaluating the patient for potential extubation. The goal would be to strike a balance between extubating in an expeditious manner without risking emergent reintubation, as this is associated with a higher VAP rate. Finally, oral intubation is favored over nasal intubation. With the exception of certain surgical procedures in the mouth or mechanical difficulties with mouth opening, it is rare that the use of nasal intubation is an appropriate first step in airway management.

iii. Semi-recumbent Position

1. Recommendation

Unless contraindicated, the semi-recumbent position should be used in patients receiving MV.

2. Rationale

The supine position is independently associated with higher rates of VAP, possibly secondary to an increased risk of gastroesophageal reflux and aspiration. One trial of 86 patients randomly assigned to either a semi-recumbent (n = 39) or supine (n = 47) position found the frequency of suspected VAP to be higher in the supine group than in the semi-recumbent group (34% vs. 8%; P=.003).¹ Similarly, the supine group exhibited an increase of micro-confirmed VAP (23% vs. 5%; P=.018). The trial was discontinued following an interim analysis because of the higher rates of VAP in the supine group. Other identified VAP risk factors included enteral nutrition, MV for 7 or more days, and a Glasgow Coma Scale score of <9. This study is commonly cited in support of the use of VAP-prevention bundles.

Using radiolabeled fluid instilled in the stomach, researchers have assayed oropharyngeal secretions, which reflect gastroesophageal reflux; and bronchial secretions, which reflect aspiration or microaspiration. One trial showed more radioactivity in the oropharyngeal and bronchial secretions in supine patients than in their semi-recumbent counterparts.² Another randomized trial demonstrated a direct association between time spent in the supine position with bronchial secretion radioactivity.³ These studies support a pathophysiologic reason for semi-recumbent patients to experience less VAP.

Interestingly, a recently published prospective, randomized animal trial investigated the effects of gravitational force on tracheal mucus transport and bacterial colonization of the respiratory system and suggests a potential negative effect of the semi-recumbent position and secretion clearance.⁴ The study involved insufflating small radio-opaque discs into sheep trachea, and then elevating the trachea 40° above or 5° below horizontal. These investigators reported that tracheal mucus moved in a retrograde fashion in those sheep in the “trachea-up” position. This would suggest that pulmonary secretion clearance would be made more difficult by the semi-recumbent position. Further, once aspirated secretions move below the endotracheal tube cuff, these secretions would tend to move away from the cords and down into the lungs. This concept becomes important when discussing tube management and cuff pressures and the potential benefit of subglottic drainage.

iv. Stress Ulcer Prophylaxis

1. Recommendation

Patients receiving MV should receive gastrointestinal (GI) stress ulcer prophylaxis.

2. Rationale

A low gastric pH theoretically serves to limit gastric microbial growth; conversely, it is thought that decreased gastric acidity would favor microbial growth. Although H₂-antagonists, antacids, and proton pump inhibitors all increase gastric pH (decrease acidity), sucralfate does not affect pH.

In the 1980s and 1990s, multiple studies investigated stress ulcer prophylaxis and VAP. Many of these studies suggested that sucralfate, compared with H₂-antagonists, decreased VAP and mortality rates. However, the effect on GI bleeding was less clear. A multi-center, blinded trial comparing sucralfate and ranitidine for the prevention of upper GI bleeding in mechanically ventilated patients was conducted to answer this question.⁵ Of the 1,200 patients studied, 596 received ranitidine and 604 received sucralfate. Ten patients in the ranitidine group compared with 23 in the sucralfate group had clinically important GI bleeding, which was defined as

hemodynamic instability requiring 2 or more units of red blood cells or a 2-g/dL drop in hemoglobin concentration. In the ranitidine group, 114 patients had VAP compared with 98 in the sucralfate group, a difference that was not statistically significant.

These results suggest that clinicians need to balance the VAP-prevention benefits of sucralfate with the reduced gastric acidity and potential development of peptic ulcer disease and GI bleeding. On balance, most have interpreted these data to favor therapies that lower gastric acidity, and VAP prevention bundles specify treatments that lower gastric acidity.

v. Endotracheal Tubes

1. Endotracheal cuff pressure

- Recommendation: Endotracheal cuff pressure should be >20 cm H₂O to limit micro-aspiration but <30 cm H₂O to limit mucosal ischemia.
- Rationale: The type of endotracheal tubes used can play a role in VAP rates. One study, which examined VAP and endotracheal tube cuff pressure, reported that a cuff pressure of <20 cm H₂O was associated with the development of VAP.⁶ However, a large body of literature demonstrates that pressure measured at the pilot balloon (where air or fluid is instilled to inflate the cuff) may be significantly different than that at the cuff.

While low cuff pressure may be associated with increased risk of VAP, likely due to aspiration around the cuff as described earlier, cuff pressure that is too high may also be harmful. Many studies have evaluated the effect of endotracheal cuff pressure and tracheal mucosal blood flow. Most recommendations suggest that a cuff pressure >30 cm H₂O is associated with impaired mucosal circulation. The ideal pressure would appear to be <30 cm H₂O to limit mucosal ischemia but >20 cm H₂O to minimize aspiration around the cuff.

2. Subglottic drainage

- Recommendation: Consider endotracheal tubes with subglottic drainage capabilities to minimize VAP if expected duration of MV is >3 days.
- Rationale: Subglottic secretions will pool above a cuff, creating a reservoir that may be aspirated. Drainage of these subglottic secretions may well decrease VAP. The reported effect of subglottic drainage on VAP has varied according to study populations. Recent meta-analyses have attempted to pool studies to increase the power to detect differences. In a recent meta-analysis, 5 randomized studies comparing subglottic secretion drainage with standard endotracheal tube care resulted in inclusion of nearly 900 mechanically ventilated patients.⁷ This meta-analysis indicated a significant association between subglottic secretion drainage and decreased VAP rates though there was no mortality benefit. Interestingly, the diagnosis of VAP was significantly delayed in patients who had a tube with subglottic drainage.

Still, there are some concerns regarding subglottic drainage. Direct tissue trauma may be related to use of these devices. Whether the tissue trauma is clinically significant is not known at this point. Another concern is the maintenance of aspiration port patency, which device manufacturers admit may be problematic. Cost may also be a consideration. Currently, a standard endotracheal tube costs approximately \$2 and one with subglottic drainage costs roughly \$12. While this cost difference is minimal, costs associated with suction canister tubing, time associated with suctioning and potential iatrogenic harm may limit the utility of these tubes.

Based on studies reporting a delay in diagnosis of VAP associated with subglottic drainage, some have advocated for the routine use of an endotracheal tube with subglottic secretion drainage in patients who have an anticipated MV duration >3 days. This seems to be a reasonable approach. However, it is difficult to determine which patients are going to remain intubated for a longer period. Furthermore, the lack of mortality benefit also must be acknowledged.

3. Endotracheal biofilm

- Recommendation: Consider silver-impregnated endotracheal tubes to minimize and delay VAP in patients with anticipated prolonged MV.
- Rationale: Biofilm is a complex bacterial structure that forms over time on the endotracheal tube. Antimicrobial prevention, for example, through the use of silver-impregnated endotracheal tubes, or mechanical elimination of biofilm has been associated with decreased bacterial burden. A recent trial reported that silver-coated endotracheal tubes were associated with decreased microbiologically confirmed VAP and delay in onset of VAP compared with uncoated tubes.⁸ However, no change in mortality, duration of intubation, ICU or hospital stay, or major complications were noted. The applicability of this study to the majority of surgical patients requiring relatively brief durations of MV is not clear. Mechanical elimination of biofilm has not been shown to decrease VAP rates. An unrelated concern about biofilm is that it can build up on the inside of the endotracheal tube, particularly with in-line suctioning.

4. Closed versus open suction

- Recommendations: Either closed or open suction systems are appropriate. Closed suction systems may be changed weekly.
- Rationale: Although biofilm build-up may be promoted with in-line suctioning, there is no evidence to recommend using a closed versus an open suction system for prevention of VAP. In a meta-analysis of 9 randomized controlled trials, Siempos and colleagues⁹ found no difference in the incidence of VAP, mortality, or length of intubation between patients treated with closed suction systems and those treated with open systems. However, multiple studies have demonstrated that when the circuit is broken to perform (open) suctioning, gas exchange is adversely affected. It has also been shown that for VAP prevention, a closed suction system need not be changed on a daily basis; every 5 to 7 days is sufficient. The caveat is to consider potential secretion buildup on the inside of the endotracheal tube which appears to be a greater problem when using in-line suctioning.

vi. Oral Decontamination

1. Recommendation

Routinely use topical oral antiseptics, such as chlorhexidine, to decrease VAP.

2. Rationale

Selective digestive tract decontamination with topical and parenteral antimicrobials has been recommended to reduce VAP rates. If micro-aspiration contributes to VAP, then decreasing microbial burden should be beneficial. Although studies suggest that both methods actually

decrease VAP occurrence rates, there is concern that the administration of parenteral antibiotics will increase antimicrobial resistance over time. Therefore, the use of parenteral administration has been discouraged.

Topical oral antiseptics, including chlorhexidine, appear to be a reasonable choice. A prospective, randomized, double-blind trial involving 353 cardiac surgery patients compared placebo and chlorhexidine gluconate for the treatment of nosocomial infections.¹⁰ The overall respiratory tract infection rate decreased 69% in the group treated with chlorhexidine gluconate. Also of note is that the use of systemic antibiotics was reduced by 43% in this patient population when chlorhexidine gluconate was administered. This association is clinically important because many patients who develop a fever or experience some other adverse event often receive systemic antibiotics. Limiting the adverse effects associated with unnecessary systemic antibiotic administration by oral antiseptics would seem to be an added benefit of such treatment.

A systematic review pooled the results of 11 randomized, controlled trials assessing the use of oral decontamination to prevent pneumonia in mechanically ventilated patients. Chan and colleagues¹¹ found that the total pooled results involving 3,242 patients favored the use of oral decontamination. Interestingly, its use had no effect on mortality rates. That does not imply that oral decontamination did not have an effect on patient outcomes—just that it did not have a mortality benefit.

vii. Other Care Processes

1. Recommendations

- Ventilator circuits do not need to be changed more often than weekly.
- No clear recommendations regarding timing and location of feeding can be made at this time.
- Oscillatory beds may decrease VAP in certain patient populations.

2. Rationale

It is well known that while microbial colonization and/or contamination may affect VAP rates, changing circuits more often than weekly does not decrease VAP occurrence rates.¹² In addition, there does not appear to be a difference in VAP rates between patients in whom heat and moisture exchangers are used and those in whom heater humidifiers are used.

Enteral nutrition has been associated with higher rates of VAP for patients in the supine position.¹ Another concern is the timing of nutrition. Some data suggest that early feeding (e.g., day 1 of MV), compared with delayed feeding (e.g., day 5 of MV), is associated with an increased risk of VAP.¹³ Still, other potential benefits of early nutrition versus late nutrition exist.

Enteric feeding tube location (pre- vs. post-pyloric) may be important. The primary concern has been that feeding into the stomach (pre-pyloric) may be associated with increased gastroesophageal regurgitation and aspiration. One randomized, controlled trial examined the effect of post-pyloric feeding on gastroesophageal regurgitation and pulmonary microaspiration by adding radioactive material to the feeds. Heyland and coworkers¹⁴ noted a statistically significant increase of radioactivity in the oropharynx of patients fed via a pre-pyloric tube. Although it did not reach statistical significance, there was a trend toward having higher radioactivity in the tracheal aspirate as well. Overall, however, other data do not suggest harm in gastric feeding and no consensus has been reached to date.

The use of oscillating beds may decrease atelectasis and improve clearance of secretions. Even though studies in surgery and neurology patients have suggested a benefit, other studies in medical and mixed populations have not. There is some concern about the beds' cost and about movement-related device morbidity. Most clinicians would argue that oscillating beds can be useful in selected patient populations, such as surgery and neurology patients, but that such beds are probably not beneficial for all mechanically ventilated patients.

viii. Multi-modal Interventions

1. Recommendation

Multi-modal interventions, such as VAP prevention bundles, with regular feedback to practitioners should be used.

2. Rationale

Various studies in recent years have reported on multi-modal interventions that have been shown to substantially reduce VAP. The interventions have been primarily education, the use of VAP-prevention bundles, and bundle compliance. Education is important not only regarding bundled care processes but also to provide staff members with feedback regarding practice implementation and compliance.

Common components of VAP-prevention bundles include:

- Head-of-the-bed elevation
- Daily sedation holiday
- Daily assessment of readiness to extubate
- Prophylaxis for peptic ulcer disease
- Prophylaxis for deep vein thrombosis

Many institutions report compliance with VAP-prevention bundles not only internally but also to external entities including government agencies and payers. Such external reporting is increasingly common and is only likely to increase. Furthermore, it is increasingly likely that such externally reported metrics will be used to “grade” delivered healthcare and influence reimbursement.

ix. Summary

Several care processes have been shown to be associated with a decrease in VAP occurrence rates when studied in ICU populations. Certain practices proven in such settings would be expected to have beneficial effects when applied to the OR setting. The individual clinician must decide which data are compelling enough to warrant implementation of a specific care process in their practice.

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F. Prevention of Infection Associated with Neuraxial Procedures

i. Background

Although rare, infectious complications of neuraxial anesthesia (predominantly epidural abscess and meningitis) may have catastrophic sequelae. The estimated incidence of epidural abscess is 1 in 145,000,¹ and most frequently associated with epidural anesthesia, while the incidence of meningitis ranges from 0.2 to 1.3 per 10,000, and associated with dural puncture.²

Review of the literature has shown the etiologic agents of neuraxial anesthesia-related meningitis to be viridans streptococci species in 49% of cases (16% *Streptococcus salivarius*), 5% *Staphylococcus aureus*, 4% *Pseudomonas aeruginosa*, 2% *Enterococcus faecalis*, and nearly 40% were either not identified or not reported. Therefore, in cases in which the organism was known, 76% of the infections involved mouth commensals, and the remainder were of skin origin.² The common etiologic agents identified in epidural-related infectious complications are: *S. aureus* (50%-60%), and streptococcal species (15%-20%),³ and are most commonly associated with chronic disease states such as alcoholism, diabetes mellitus, immunocompromised states, and chronic renal failure.⁴

Post-dural puncture meningitis typically manifests between 6 and 36 hours after dural puncture with a headache that may be mistakenly attributed to a more innocuous etiology, but rapidly progresses to include: neck pain/rigidity, fever, back pain, nausea, vomiting, confusion, lethargy, seizures; and if untreated, death within 24 hours. The cerebrospinal fluid (CSF) may become inoculated via contaminated needles, syringes, medications, hands/gloves; breaches of the sterile field; inadequate disinfection of the patient's skin; or droplet contamination from the upper airway of the proceduralist or others in the room.² Infectious complications from epidural procedures may have a more variable time course and result from axial spread and spinal cord compression. The presenting symptoms are typically fever, back pain/tenderness, and radicular pain leading to weakness and paralysis.⁵

In recognition of the problem of infections related to peri-axial anesthesia, the ASA established a task force that has developed evidence-based recommendations entitled "Practice Advisory for the Prevention, Diagnosis, and Management of Infectious Complications Associated with Neuraxial Techniques." The full text of this statement can be found in the March 2010 issue of *Anesthesiology*, or downloaded from the ASA Web site (<https://ecommerce.asahq.org/p-349-practice-advisory-for-the-prevention-diagnosis-and-management-of-infectious-complications-associated-with-neuraxial-techniques.aspx>). The Table below is a synopsis of their findings.

Table: Summary of Advisory Statements

Recommendations⁶	Rationale
<i>Prevention of Infectious Complications</i>	
Perform history and physical examination with attention to conditions that may increase the risk of neuraxial infection and consider risks/benefits of alternative techniques.	Cancer, diabetes, impaired immune response, pancreatitis, GI bleeding, drug or alcohol abuse and pre-existing infection or bacteremia may be associated with an increased risk of infection after neuraxial procedures. ⁶
Consider pre-procedure (prophylactic)	Controlled studies in animals and some

antibiotics if patient is bacteremic.	retrospective human data suggest a decreased incidence of meningitis if antibiotics are administered prior to dural puncture in the setting of bacteremia. ⁷
Avoid lumbar puncture (LP) in patients with a known epidural abscess	Consultant/ASA member agreement. ⁶
Aseptic technique should always be utilized when performing neuraxial techniques. These include:	Retrospective/observational correlations and extrapolation from central line insertion practice data support the use of aseptic technique ⁶
<ul style="list-style-type: none"> • Removal of jewelry 	<ul style="list-style-type: none"> • Jewelry carries increased bacterial counts despite hand hygiene.⁶
<ul style="list-style-type: none"> • Hand washing- Hand hygiene with alcohol-based hand gel or soap and water should be performed prior to all sterile procedures and following the removal of gloves. 	<ul style="list-style-type: none"> • Hand washing has been demonstrated to be the single most effective means of preventing healthcare-associated infections (HAIs) dating back to Semmelweis (1847).
<ul style="list-style-type: none"> • Wear cap, mask, sterile gloves 	<ul style="list-style-type: none"> • Wearing of surgical caps reduces ambient bacterial contamination. Surgical masks decrease sterile field contamination with nasal and oropharyngeal commensal bacteria. Efficacy is reduced beyond 15 min of use, which advocates for the donning of a fresh mask for each procedure.^{8,9} No recommendation on wearing a sterile gown.⁶
<ul style="list-style-type: none"> ▪ Use of individual packets of antiseptic skin preparation (preferably a chlorhexidine/alcohol solution). 	<ul style="list-style-type: none"> ▪ Evidence indicates greater efficacy of skin disinfection with chlorhexidine/alcohol solutions.¹⁰⁻¹³ Additionally, contamination of multi-dose preparations has been demonstrated.
<ul style="list-style-type: none"> ▪ Sterile drape. 	<ul style="list-style-type: none"> ▪ No recommendation on size of drape.
<ul style="list-style-type: none"> ▪ Sterile/ occlusive dressing over catheter site. 	<ul style="list-style-type: none"> ▪ Despite insufficient data, consultants and ASA members strongly agree that this is best practice.
Consider in-line bacterial filter for extended infusions.	Unresolved issue.
Limit the number of disconnections of the catheter/ infusion system.	Insufficient data, but strong agreement that a closed system minimizes potential bacterial contamination.
Consider removing catheter if an unwitnessed disconnection occurs.	ASA task force opinion.
Remove catheter as soon as no longer clinically necessary.	No data to support specific duration, but strong correlation with increased incidence of infection with increasing duration.
<i>Diagnosis of Infectious Complications</i>	
Daily evaluation of catheter site.	Fever, backache, erythema, or tenderness at the insertion site may be early signs of infection with an indwelling catheter.
Prompt evaluation of any signs/symptoms of	

infectious complications:	
<ul style="list-style-type: none"> Remove catheter, consider culturing tip. 	<ul style="list-style-type: none"> Consultant and ASA member opinion.
<ul style="list-style-type: none"> Obtain laboratory workup and cultures. 	<ul style="list-style-type: none"> Consider: leukocyte count, sedimentation rate, and C-reactive protein, blood and CSF cultures to identify the etiologic agent.
<ul style="list-style-type: none"> Evaluate for neurologic dysfunction, obtain appropriate consultations and imaging studies. 	
<i>Management of Infectious Complications</i>	
Antibiotic treatment (empiric, broad-spectrum).	
Consultation with appropriate physicians (e.g., infectious disease specialists, surgical consultation).	

LP = lumbar puncture.

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G. Prevention of Transmission of Multi-drug–Resistant Organisms

i. Background

A multi-drug–resistant organism (MDRO) is one that is resistant to 1 or more classes of antimicrobial agents. Drug resistance to methicillin was first described in *Staphylococcus aureus* (MRSA) in 1968. By the early 1990s, 20% to 25% of *S. aureus* isolates in hospitalized patients were MRSA. In 2003, 59.5% of *S. aureus* isolates from intensive care unit (ICU) patients in the United States were methicillin resistant. Strains of *S. aureus* with intermediate resistance (VISA) and full resistance (VRSA) to vancomycin have now been identified.¹ Other MDROs include:

- Vancomycin resistant *Enterococcus* (VRE)
- Multi-drug–resistant gram-negative bacilli (MDR-GNB)
 - *Klebsiella pneumoniae*: Resistance to third-generation cephalosporins
 - *Acinetobacter baumannii*: Resistance to carbapenems
 - *Pseudomonas aeruginosa*: Resistance to carbapenems and fluoroquinolones
 - *Escherichia coli*: Resistance to fluoroquinolones
 - *Burkholderia cepacia* and *Ralstonia pickettii*: Resistant to broadest-spectrum antibiotics
- Multi-drug–resistant *Streptococcus pneumoniae*: Resistant to penicillin, macrolides, fluoroquinolones¹

ii. Recommendations

Standard and contact precautions are recommended in the immediate vicinity and during care of patients infected with MDROs that have been targeted as a transmission risk.¹ This includes the use of a gown and gloves. Masks and eye protection should be worn when there is the risk of splash or droplet dispersal (tracheostomies, suctioning, intubation). When possible, dedicated equipment should be used for patients who require contact precautions to minimize the risk of these items acting as fomites for the transmission of microorganisms. Equipment and environmental surfaces should be routinely cleaned between patients with an emphasis on high touch areas. Decolonization of MDRO carriers is not routinely recommended unless there is evidence that the individual has been linked to transmission. Susceptibility testing of the organism should be performed prior to decolonization.¹ The presence of an MDRO requiring special precautions should be reported during the transfer of care.

iii. Rationale

The National Nosocomial Infections Surveillance (NNIS) System estimates that 10% of patients admitted to a hospital will develop a healthcare-associated infection (HAI)² and the incidence of infection with an MDRO is increasing. MDROs are associated with increased lengths of hospitalizations, cost, and mortality.¹ Increasingly, state legislatures are enacting bills in an attempt to mandate procedures to reduce and prevent the transmission of MDROs. Healthcare payers are linking reimbursement to compliance with quality improvement practices.

Transmission and persistence of organisms in the healthcare setting is dependent on a reservoir of susceptible individuals (those with: indwelling catheters, endotracheal tubes, compromised host defenses), antimicrobial selection pressure, and lack of adherence to prevention measures.¹ Healthcare workers' hands are the most common vector for transmission. A recent study demonstrated a direct correlation between the contamination of 2 high touch areas of the anesthesia machine (adjustable pressure-limiting valve [APL], agent flow dial) and positive culture results on the internal surface of intravenous stopcocks. This correlated with an increased mortality risk, though the trend toward increased HAI did not reach statistical significance.³

Fomites may also serve as a source of transmission of HAIs. Several studies have shown clothing, jewelry, artificial nails, and equipment (including stethoscopes) may become contaminated with MDROs during routine patient care.⁴⁻⁸ Disinfection of equipment between patients, appropriate hand hygiene (see recommendations), and the use of gowns that are removed immediately following the care of a patient with an MDRO will minimize the risk of transmission.

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H. Pediatric Considerations

i. Skin Antisepsis for Insertion and Maintenance of Venous and Arterial Lines

1. Recommendation

No specific agent has been recommended for skin antisepsis prior to invasive procedures in preterm infants and infants less than 2 months of age.¹

2. Rationale

Chlorhexidine gluconate (CHG), alcohol, and povidone-iodine have all been shown to be effective in reducing skin colonization in neonates, but issues of systemic toxicity need to be addressed in this population. The permeability to topical agents is many times greater in preterm skin than in adult skin and increases inversely with gestational age.² Povidone-iodine solutions have been associated with transient suppression of thyroid function and goiter formation in neonates.^{3,4} Alcohol has been associated with skin reactions including necrosis and systemic toxicity⁵ so many institutions do not use alcohol products in preterm infants. The addition of alcohol to CHG or iodine skin preparations to speed drying has been associated with enhanced systemic absorption of these preparations so it is not recommended. In addition, no commercially available CHG product has received FDA approval for use in infants <2 months of age. It is recommended that extreme care be taken to minimize skin contact and avoid pooling of skin disinfectants in preterm infants and neonates and to clean off disinfectants with sterile water rather than alcohol.

ii. Cystic Fibrosis

1. General information

Cystic fibrosis (CF) is a multi-system disease in children and adults characterized by dysfunction of exocrine glands leading to chronic lung infections and disorders of the digestive system. It is also associated with pancreatic malfunction including insulin-dependent diabetes. Approximately 3% to 4% of Caucasian populations are carriers of this disease, which is inherited in an autosomally recessive manner. Recently, interest in infection control in CF has increased because patient-to-patient transmission of pathogens has been increasingly demonstrated in this patient population.⁶

Staphylococcus aureus, *Haemophilus influenza*, and *Pseudomonas aeruginosa* are the most common pathogens that infect the lungs of CF patients, but *Burkholderia cepacia* complex, *Stenotrophomonas maltophilia*, *Achromobacter xylosoxidans*, aspergillus, non-tuberculous mycobacteria, and respiratory viruses are also important pathogens.

2. U.S. CF Foundation Consensus Guidelines 2003 were devised to craft recommendations for infection control for CF care providers^{6,7}

- General principles for healthcare settings:

- Assume that all CF patients could have transmissible pathogens in respiratory tract secretions.
- Apply standard precautions to all CF patients to contain their secretions and to minimize the potential for CF patients to come in contact with the secretions of other CF patients.
- Implement standard plus transmission-based precautions according to CDC/HICPAC published recommendations for the use of contact, droplet or airborne precautions as defined by special circumstances, e.g., *B. cepacia* complex, multi-drug-resistant *P. aeruginosa*, MRSA, or *Mycobacterium tuberculosis*.
- Avoid activities or risk factors that have been associated with the transmission of pathogens in CF patients, which include sharing hospital rooms, sharing hospital equipment, and socializing with other CF patients.
- No recommendation for criteria to discontinue contact precautions for CF patients with epidemiologically important pathogens, e.g., *B. cepacia* complex.

3. Elective surgery on patients with CF

- Recommendations: Elective surgery is permitted on patients with CF. All HCWs should observe standard precautions when caring for patients with CF, and all CF patients who are infected or colonized with MRSA, *B. cepacia* complex, multi-drug-resistant *P. aeruginosa*, respiratory syncytial virus, parainfluenza virus, or VRE should be placed on contact precautions. Patients infected with adenovirus should be placed on contact and droplet precautions and those infected with influenza should be on droplet precautions in addition to standard precautions.
- Rationale: These recommendations are in place to prevent the transmission of these pathogens from colonized or infected CF patients to other CF patients or HCWs. The most common pathogens are spread by close contact, either direct or indirect, with the respiratory secretions from another patient with CF. Therefore all CF patients must be educated about containing their secretions and maintaining a distance of more than 3 feet from other CF patients even if culture results are negative or unavailable. Wait times in common areas such as preoperative clinics or preoperative holding areas should be minimized, and strategies should be used to minimize contact between patients with CF in common waiting areas.

4. Recovery from anesthesia

- Recommendations: CF patients on transmission-based precautions should be recovered following healthcare facility policy. Single rooms are preferred whenever possible. Care should be taken to separate CF patients from each other.
- Rationale: It is important to separate CF patients from each other in and outside the hospital to decrease the risk of patient-to-patient transmission of pathogens. Patients known to be colonized with the pathogens listed earlier must be isolated from other patients with and without CF. A significant proportion of the CF population is pediatric, therefore, it is important to consider the psychological effects of isolation in healthcare settings on these patients. Family members and friends should be allowed to stay with these young patients during the recovery process. Patients should be allowed to have their

favorite toys and comfort objects but they should not be taken from the patient's bedside because they can serve as fomites for transmission.

iii. Patients with a Communicable Disease: (Varicella-Zoster, Measles, Pertussis)

1. Elective surgery

- Recommendations: If feasible, elective surgery for a patient with a communicable disease or exposure to a communicable disease should be delayed until the patient is no longer infectious or the incubation period has elapsed.
- Rationale: Patients who have been exposed to a communicable disease risk infecting other patients and healthcare workers. During their preoperative visit all pediatric patients should be screened for their immunization status and recent exposure to infectious diseases. Vaccination or proof of immunity against a number of infections (including varicella-zoster and measles) should be documented for all healthcare workers according to published guidelines.⁸⁻¹¹

2. Non-elective surgery

- **Susceptible patients** who have been exposed to varicella need to be placed on airborne precautions beginning 8 days after first exposure and continued up to 21 days after last exposure (and up to 28 days if they have received varicella zoster immunoglobulin). Patients with active varicella need to be on airborne and contact precautions until all lesions are crusted, usually 5 to 7 days after onset. Susceptible patients who have been exposed to measles need to be placed on airborne isolation precautions from 5 days after first exposure to 21 days after last exposure. Those who have active measles need to be on airborne precautions until 4 days after the onset of rash.
- **Susceptible healthcare workers** should not be involved in patient care, and patients should be confined to their rooms unless it is absolutely necessary to transport them. Patients should wear a surgical mask if they are transported and procedures should be scheduled at a time when potential exposure to staff and other patients is minimal. If it is necessary for susceptible HCWs to care for the patient, then they must wear a hospital-approved respirator (such as an N95 or a powered air purifying respirator [PAPR]).
 - Patients with known or suspected pertussis should be placed on droplet precautions until 5 days after the patient begins effective therapy or for 3 weeks after the onset of paroxysms. HCWs who are exposed to pertussis should be given chemoprophylaxis and those who display symptoms of pertussis should be excluded from work for the first 5 days of the recommended antimicrobial therapy. Patients should wear a surgical mask if they are transported, and procedures should be scheduled at a time when exposure to staff and other patients is minimal.
 - Many pediatric patients are exposed or infected with other communicable pathogens and thus it is recommended for HCWs to follow current CDC guidelines for infection control. The infection control department of individual healthcare facilities must be consulted to assist in the care of patients who are exposed to or infected with a communicable disease.

3. Recovery from anesthesia

- Recommendations: During recovery from anesthesia, patients exposed or infected with varicella, measles, or pertussis should be monitored and placed in a private room.
- Rationale: Patients on airborne precautions should be recovered in a private airborne infection isolation room. If such a room is not available in the postoperative acute care unit, then recovery of the patient should occur in a private room with the door closed at all times in the operating suite or the PACU, or in the patient's hospital airborne infection isolation room on the floor. Appropriate monitoring and emergency equipment must be available in these locations. Patients on droplet and contact precautions are best recovered in a private room but there is no need for special airflow.

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I. Disinfection of Equipment

Anesthesia equipment is exposed to microorganisms from multiple sources during routine use and handling. Proper infection control procedures are essential to minimize the risk of this equipment becoming a vector in the transmission of health-care associated infection. As contamination cannot always be determined visually, all used equipment should be considered contaminated and appropriately disinfected prior to reuse. Unused equipment may be exposed to infectious agents in many ways, including: contaminated hands of healthcare workers (HCWs), splash, spill, or contact with used equipment. Care should be taken to avoid such contamination, as these items will require the same handling as used equipment.^{1,2}

Spaulding established the current classification system that has been in use for over 40 years. Instruments are classified as critical, semi-critical, or non-critical based on their intended use.

- **Critical** items are those that will contact normally sterile tissues and must therefore be sterile at the time of use.
- **Semi-critical** devices contact mucous membranes or non-intact skin and require high-level disinfection.
- **Non-critical** devices will touch only intact skin and require intermediate or low-level disinfection.³

i. Equipment Requiring Sterilization

1. Recommendation

Critical devices (those entering normally sterile tissue) must be sterile at the time of use. Avoid contamination during use by using aseptic technique.

2. Rationale

Critical devices include vascular needles and catheters, regional needles and catheters, all devices used while accessing the epidural or intrathecal space, intravenous (IV) tubing, stopcocks (and injection ports), and syringes. Most critical items used in the delivery of anesthesia are single use items (see section on single-use equipment) and will therefore not require reprocessing. Sterilization destroys all forms of microbial life including bacterial spores (exclusive of prions). Manufacturers' instructions regarding cleaning of equipment should always be followed to avoid damage to the integrity and/or function of the device.^{1,3}

3. Techniques

Examples of sterilization techniques³:

- *High temperature*: Steam sterilization for ~40 minutes, or dry heat for 1 to 6 hours (depending on temperature)
- *Low temperature*: Ethylene oxide (ETO) gas for ~15 hours, or hydrogen peroxide gas plasma for ~50 minutes
- *Liquid immersion* (chemical sterilants)
 - ≥2.4% glutaraldehyde for ~10 hours
 - 1.12% glutaraldehyde and 1.93% phenol for 12 hours
 - 7.35% hydrogen peroxide and 0.23% peracetic acid for 3 hours
 - 7.5% hydrogen peroxide for 6 hours
 - 1.0% hydrogen peroxide and 0.08% peracetic acid for 8 hours
 - ≥ 0.2% peracetic acid for ~50 minutes at 50°C-56°C

ii. Equipment Requiring High-Level Disinfection

1. Recommendation

Equipment that will contact mucous membranes or non-intact skin should be free of contamination at the time of use. A filter that protects the anesthesia machine from contamination should be used in the circuit to avoid exposure of the machine to microorganisms.^{1,3}

2. Rationale

High-level disinfection destroys all microorganisms except high numbers of bacterial spores (prions excepted). This equipment includes, but is not limited to laryngoscopes, face masks, laryngeal airways, oral/nasal airways, light wands, bronchoscopes, endotracheal tubes, transesophageal echocardiography probes, esophageal/rectal temperature probes, and the anesthesia circuit.^{1,3,4}

Medications and equipment used in conjunction with endotracheal tubes (lubricant, stylets, suction catheters) may introduce microbes into the airway and must therefore be free of contamination. Moisture that accumulates in the breathing circuit may be a source of bacterial growth and should periodically be drained (away from patient) from the circuit.¹

Internal components of the anesthesia machine should be cared for according to the manufacturer's recommendations. Unidirectional valves, carbon dioxide absorbent chambers, and bellows should be cleaned and disinfected periodically. Moisture that accumulates in the machine should be removed. Routine bacterial culture monitoring of the anesthesia machine is not indicated. In the case of reuse of anesthesia circuits that are marketed as single use devices, standards applicable to the original manufacturer apply to those who subsequently reprocess the equipment (see single use equipment section).¹

3. Techniques

Examples of high-level disinfection techniques³:

- *Heat automated*: Pasteurization for ~50 min.
- *Liquid immersion* (chemical sterilants or high-level disinfectants)
 - 2% glutaraldehyde for 20 to 45 minutes
 - 0.55% ortho-phthalaldehyde for 12 minutes
 - 1.12% glutaraldehyde and 1.93% phenol for 20 minutes
 - 7.35% hydrogen peroxide and 0.23% peracetic acid for 15 minutes
 - 7.5% hydrogen peroxide for 30 minutes
 - 1.0% hydrogen peroxide and 0.08% peracetic acid for 25 minutes
 - 650 to 675 ppm chlorine for 10 minutes

Fiberoptic bronchoscopes require special processing to ensure both disinfection/sterilization and avoid damage to the equipment. Endoscopes that contact only mucous membranes should undergo a minimum of high-level disinfection. Those that enter sterile spaces require sterilization. Manufacturers' recommendations should be followed as they recommendations differ somewhat based on the construction of the device. The process should include¹:

- Leak testing of the endoscope. If the device fails leak testing, it cannot undergo cleaning without risking further damage. The manufacturer should be contacted regarding repair.
- Mechanical cleaning of all surfaces, including internal channels, with a low-sudsing enzymatic detergent as soon as possible after use to avoid drying of organic material that may later interfere with the effectiveness of disinfection/sterilization. Organic material retained in the internal channel of endoscopes poses the greatest risk of infection for subsequent patients. All channels of the endoscope should be irrigated and cleaned with a

brush to remove particulate matter. Brushes should be either disposable or undergo cleaning and disinfection daily when used.

- Endoscopes should then undergo a minimum of high-level disinfection with a chemical disinfectant. Channels within the scope must be perfused with the disinfection solution throughout the processing.
- Rinse both internally and externally to remove disinfectant.
- Dry both internally and externally. Ethyl alcohol (70%) and compressed air through the channel will facilitate drying.
- Endoscopes should be stored in a manner that prevents recontamination and promotes drying (hung vertically).

iii. Equipment Requiring Intermediate or Low-Level Disinfection

1. Recommendation

Equipment that contacts only intact skin should be cleaned when soiled. Frequently touched surfaces should be considered contaminated and cleaned after each case.^{1,3}

2. Rationale

Intermediate-level disinfection kills vegetative bacteria, mycobacteria, most viruses, and most fungi, but not bacterial spores. These products are Environmental Protection Agency (EPA)-registered disinfectants with tuberculocidal activity. Low-level disinfectants kill vegetative bacteria, some fungi and viruses, but not mycobacteria or spores. Manufacturers' instructions should be followed regarding concentration and contact time.⁵

Non-critical devices include, but are not limited to blood pressure cuffs, pulse oximeters, stethoscopes, cables, and surfaces of the anesthesia machine and cart.¹

3. Techniques

- *Intermediate-level disinfection* (liquid contact)³
 - EPA-registered hospital disinfectants with tuberculocidal activity, such as chlorine and phenol products for a minimum of 1 minute.
- *Low-level disinfection* (liquid contact)³
 - EPA-registered hospital disinfectants with no claim of tuberculocidal activity. Includes chlorine-based products, phenolics, quaternary ammonium compounds, and 70% to 90% alcohol.

iv. Single-Use Equipment

1. Recommendation

The reuse of disposable equipment is not recommended.

2. Rationale

Re-use of most disposable equipment will require sterilization or disinfection of the device. Processing of equipment may damage or weaken the integrity of the item making it unsafe and/or inaccurate. Reuse of disposable equipment shifts liability for the product from the original manufacturer to the reprocessor. In addition, there are multiple legal requirements, mandated by the FDA, that must be met when reprocessing single-use devices.¹

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III. PREVENTION OF OCCUPATIONAL TRANSMISSION OF INFECTION TO ANESTHESIOLOGISTS

A. Needlestick/Sharps Safety

i. Preventing Accidental Needlesticks and Other Sharp Object Injuries

1. Recommendations

Reduce the risk of sharp object injuries to healthcare personnel through routine use of needleless devices (e.g., stopcocks, needleless access ports and valves), needle products with needlestick protection safety features, scalpels with safety-activated blade covers, and other devices with safety protection features.

Handle needles and other sharp devices in a manner that will prevent injury to the user and others who may encounter the device during or after a procedure.

Contaminated needles must not be bent, recapped, or removed from syringes unless such action is required by a specific procedure or has no feasible alternative. If a needle must be recapped, a mechanical device or a “1-handed” technique should be utilized. (The needle must never be directed toward the other hand. A mechanical device may be used to hold the cap. In the “1-handed” technique, the needle is “scooped” into a needle cap that is not being held, and then seated onto the needle hub. Needle cap perforation by the needle is possible when recapping with either technique, therefore observe caution.) Shearing or breaking of contaminated needles is not permitted.

Puncture-resistant, leak-proof containers for disposal of used needles and syringes, scalpel blades, and other sharp items should be located as close as is feasible to the immediate area where sharps are used. Sharps containers must be sealed and replaced before completely filled.

2. Rationale

The prevention of sharps injuries has always been an essential element of Universal and now Standard Precautions.¹⁻³ The United States Needlestick Safety and Prevention Act of 2000, effective July 2001, authorized the revision of the Occupational Safety and Health Administration (OSHA) Bloodborne Pathogens Standard to more explicitly require use of safety-engineered sharp devices.⁴ The Centers for Disease Control and Prevention (CDC) has provided guidance on sharps injury prevention including the design, implementation, and evaluation of a comprehensive sharps injury prevention program.⁵⁻⁷

Engineering controls are devices, with or without a needle, with built-in safety features that remove or isolate a potentially infectious hazard.⁵⁻⁷ Examples include needleless intravenous access systems, self-sheathing needles, safety intravenous catheters, recessed needles, and

sharps disposal containers. Safety mechanisms should be built into the device rather than added on. It is preferable to use passive safety mechanisms (automatic mechanisms that do not require user activation) rather than active safety mechanisms (the user might fail to activate the safety feature, and some active safety features can be circumvented). Active safety features should keep the user's hands behind the exposed sharp. Healthcare workers (HCWs) should become familiar with and use the safest devices available.

The implementation of safety engineered devices as required by the Needlestick Safety and Prevention Act of 2000 has been shown to reduce percutaneous injury rates, with injuries involving hollow-bore needles showing the most significant decrease.⁸

Work practice controls reduce or eliminate exposure risk by altering how a task is performed (e.g., prohibiting recapping of needles by a 2-handed technique).⁵⁻⁷ Avoid needle recapping unless absolutely necessary and then recap with 1-hand recapping or a safety device. Avoid unnecessary use of needles and other sharp devices and use care in handling and disposal.

The injury rate for straight suture needles is more than 7 times the rate associated with conventional instrument-held curved suture needles.⁹ Use a curved needle with a needle holder for suturing rather than holding a straight needle by hand and avoid holding patient tissues with fingers when suturing or cutting.¹⁰ Double gloving offers significantly reduced perforations to innermost gloves, which increases protection from penetrating injuries to the hands compared with wearing a single pair.¹¹ The use of gloves may also decrease the risk of infection by decreasing inoculum size from some types of needlestick injuries.¹²⁻¹⁴

The cumulative risk of occupational infection with bloodborne pathogens depends on (1) the number and type of exposures to patients' blood or body fluids, (2) the prevalence of infected patients in the HCWs practice, and (3) the risk of infection transmission after each pathogen-contaminated exposure.¹⁵

Injuries to healthcare personnel from needles and other sharp objects have been associated with transmission of human immunodeficiency virus (HIV), hepatitis B virus (HBV), and hepatitis C virus (HCV).^{16,17} The greatest risk of transmission of bloodborne infections with HIV, HBV, and HCV is from a blood-contaminated percutaneous injury. The risk depends on the type of pathogen involved and increases when the source patient has higher viral titers (for HIV, HBV, HCV, respectively: acute or terminal HIV illness; hepatitis B e-antigen positive source; increased HCV RNA titers) and with increased quantity of inoculum volume transferred from the source patient. Risk factors for transmission of HIV, HBV, or HCV include a deep injury and a procedure involving a needle placed directly in the source patient's vein or artery (a hollow-bore needle); for HIV the risk has been documented to increase if there is visible blood on the sharp device.¹⁶⁻²²

The average risk of acquiring HIV infection after an accidental parenteral exposure (needlestick or cut) to blood from a known HIV-infected patient is estimated to be 0.3%.²³

Although the average risk of HIV infection after all types of reported percutaneous exposures to HIV-infected blood is 0.3%, the risk, although not quantified, exceeds 0.3% for an exposure involving a greater infectious dose resulting from transfer of a larger blood volume, a higher HIV titer in the source patient's blood, or both.¹⁶

After a blood-contaminated percutaneous exposure when the source patient is hepatitis B surface antigen (HBsAg) positive and hepatitis B e antigen (HBeAg) negative the risk of HBV transmission to a non-immune HCW resulting in clinical hepatitis was 1% to 6% and the risk of developing serologic evidence of HBV infection was 23% to 37%. In comparison, after a blood-contaminated percutaneous exposure from a source patient with blood positive for both HBV antigens, the risk to the HCW of clinical hepatitis was 22% to 31% and the risk of developing serologic evidence of HBV infection was 37% to 62%.¹⁶

The average risk of HCV seroconversion is less than that reported in earlier studies. The previously reported average risk of HCV seroconversion after percutaneous exposure was 1.8% (range: 0%-7%) involving 449 exposed HCWs in 3 studies.¹⁶ In 2002, Jagger et al reported an overall average transmission rate of 0.5% (59/11,324) when data from 14 studies were combined.²⁴ Data from studies in 2003 also determined that the average risk of HCV transmission after percutaneous exposure to anti-HCV-positive blood is lower than initially reported: 0.3% (14/4,403 exposures and 2/684 HCWs).^{22,25} The HCV seroconversion risk after injury with an anti-HCV-positive hollow-bore blood-filled needle was higher than the risk for all percutaneous injuries combined: 0.74% (14/1,876) vs. 0.3% (14/4,403).²²

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B. Transmission-Based Precautions¹

i. Modes of Transmission

1. Direct contact transmission

This is the transmission of an infectious agent directly from 1 person to another. This may occur via contact of blood or secretions with mucous membranes, open cuts, or mites.

2. Indirect contact transmission

This occurs when an infectious agent is transmitted via an intermediate object (fomite) that has been previously contaminated. This may include, but is not limited to patient-care devices, environmental surfaces, and clothing.

3. Droplet transmission

This is a specific type of contact transmission. Droplets are formed when a person coughs, sneezes, talks, sings, and during endotracheal intubation and suctioning. Droplets are defined as being $>5 \mu\text{m}$. They remain suspended for short periods and tend to be deposited within 3 feet of where they are generated. The distance that a droplet travels may be affected by factors such as temperature, humidity, and air currents. It is recognized, however, that the particle size of emitted respiratory secretions is a continuum from aerosol size particles ($\leq 5 \mu\text{m}$) to droplets ($>5 \mu\text{m}$). Droplets are preferentially deposited in the upper airways, whereas aerosols penetrate deeper into the lower respiratory tract.

4. Airborne transmission

This occurs with organisms that can remain infectious when disseminated over distance and time as the droplet nuclei ($\leq 5 \mu\text{m}$ particles) are dispersed on air currents.

ii. Transmission Based Precautions

1. Standard precautions

These precautions reduce the risk of transmission of infectious agents from patient to patient, patient to health care worker (HCW), or HCW to patient.

- Apply to all patients, as anyone may be infected or colonized with a transmissible disease.
- Wear gloves for all contact with blood, body fluids (except sweat), non-intact skin, and mucous membranes. Change gloves when they become soiled or when contact with a clean body part follows that with a contaminated part. Remove gloves after patient contact. Minimize environmental contamination.
- Perform hand hygiene before patient contact and upon removal of gloves. See section on hand hygiene.
- Gown, face, and eye protection should be worn if there is a risk of splash or spray.
- Environmental cleaning after contamination by body substances.
- Use a standard surgical mask when inserting a central line or performing neuraxial anesthesia.
- Needle and sharp safety: Avoid recapping (when necessary, use 1-handed technique), bending or breaking used sharps. Dispose sharps in appropriate puncture-resistant container. See safe injection practices section.

- Practice and encourage respiratory hygiene/cough etiquette.

2. *Contact precautions* (in addition to standard precautions)

- Private patient room or cohort patients. Spatial separation of ≥ 3 feet between patients recommended.
- Signage outside room to indicate level of precautions.
- Gown and glove upon entering room and with any patient or environmental contact.
- Face and eye protection if there is a risk of splash or spray.
- Remove gloves and gown before exiting room. Care must be used to avoid self-contamination when removing personal protective equipment (PPE).
- Perform hand hygiene after removal of PPE.
- Dedicated patient equipment whenever possible. Appropriately clean equipment prior to its use with other patients. See “Disinfection of Equipment.”
- Appropriate cleaning of room when vacated.
- Maintain contact precautions during transport and entire perioperative period.
- Communicate precaution level to those who will receive patient postoperatively.

3. *Droplet precautions* (in addition to standard precautions)

- Single patient room optimal. May cohort or with existing roommate when necessary.
- Spatial separation of patients ≥ 3 feet. If curtain present, keep drawn.
- Signage outside room to indicate level of precautions.
- HCWs should wear standard surgical mask, gloves, gown, and eye protection as required under standard precautions.
- Patient should wear standard mask (if tolerated) when transport outside room required.
- Respiratory hygiene/cough etiquette.
- Maintain precautions throughout perioperative period.
- Communicate precaution level to those who will receive patient postoperatively.

4. *Airborne precautions* (in addition to standard precautions)

- Place patient in an airborne isolation room (AIIR). See “Glossary.”
- Signage outside room to indicate level of precautions.
- N95 respirator or greater protection should be used when in the patient’s room.
- Patient should remain in AIIR with door closed at all times, except for medically necessary procedures.
- Elective procedures should be postponed until patient no longer requires respiratory isolation.
- Patients should wear a standard surgical mask when transported outside the AIIR. The purpose of the mask is to prevent respiratory droplets from being expelled into the environment where they can become droplet nuclei.
- Operating rooms (ORs) are designed to be positive pressure in relation to the environment. Therefore, it is important to choose the most appropriate OR to minimize the risk of contaminating the OR suite. Options include the OR that is most remote from others, one with an antechamber, or one in which a portable negative pressure isolation chamber can be installed at the door.
- The surgical procedure should be scheduled at a time when it will minimize exposure of other patients and medical staff to the airborne infectious disease.
- Post-anesthesia recovery must take place with the same level of respiratory precautions.
- Communicate precaution level to receiving personnel.

- Room should remain vacant after the patient leaves until adequate time has elapsed to result in a 99.9% air turnover (duration dependent on number of air exchanges per hour in room).²

Table: Agent, Type, and Duration of Precautions*

Infection/Condition	Precautions	Comments
Abscess		
Draining/major	Contact	
Draining/minor	Standard	
HIV	Standard	Post-exposure prophylaxis (PEP) for some exposures
Avian influenza	Droplet	Enhanced precautions (i.e., airborne may be recommended)
Bronchiolitis	Contact	
<i>Clostridium</i>		
<i>botulinum</i>	Standard	Not transmitted person to person
<i>difficile</i>	Contact	
<i>perfringens</i>	Standard	Not transmitted person to person
Conjunctivitis		
Bacterial	Standard	
Viral	Contact	Most commonly: Adenovirus, enterovirus, Coxsackie virus A24
Creutzfeldt-Jakob disease	Standard	Single use equipment preferred, special cleaning (NaOH, heat, and time requirements) for contaminated instruments and environment
Diphtheria pharyngeal	Droplet	Until 2 cultures >24 h apart are negative
<i>E. coli</i>	Standard	Contact precautions if patient incontinent
<i>Haemophilus influenzae</i>		
Seasonal	Droplet	Single patient room or cohort, gown and glove
Pandemic	Droplet	Enhanced precautions (airborne may be recommended)
Hepatitis, viral		
A	Standard	Contact precautions for incontinent patients
B	Standard	
C	Standard	
E	Standard	Contact precautions for incontinent patients
Herpes, zoster (varicella-zoster)		
Disseminated	Airborne, contact	
Localized	Standard	HCW without immunity should not care for patient if immune HCW available.
Impetigo	Contact	
Legionnaires disease	Standard	Not transmitted person to person
Lice		
Head	Contact	
Body	Standard	
Pubic	Standard	
Lyme disease	Standard	
Malaria	Standard	

Measles	Airborne	Susceptible HCW should not care for patient if immune HCW available. Maintain precautions for 4 days after onset of rash. Non-immune exposed individuals may be infectious from day 5-21 after exposure. PEP available (vaccine, immune globulin)
Meningitis		
Bacterial	Standard	
Fungal	Standard	
<i>Neisseria</i>	Droplet	
<i>Streptococcus</i>	Standard	PEP available
MDROs: MRSA, VRE, VISA/VRSA, ESBLs, resistant <i>S. pneumoniae</i>	Standard/contact	
Mumps	Droplet	Susceptible HCWs should not care for patient if immune HCW available.
<i>Mycoplasma</i>	Droplet	
<i>Mycobacterium tuberculosis</i>	Airborne	
Parainfluenza	Contact	
Pertussis	Droplet	Single patient room or cohort. PEP available. Tdap recommended.
Poliomyelitis	Contact	
Rabies	Standard	
Respiratory syncytial virus	Contact	Standard mask should be worn.
Rhinovirus	Droplet	
Rubella	Droplet	Susceptible HCW should not care for patient if immune HCW available. Vaccine available. Non-immune exposed individuals may be contagious from day 5-21 after exposure.
<i>Salmonella</i>	Standard	Contact precautions for incontinent patients.
SARS-CoV	Airborne, Droplet, Contact	Maintain precautions until 10 days after resolution of fever.
Shigella	Standard	Contact precautions for incontinent patients.
Smallpox	Airborne, contact	Maintain precautions until all scabs have crusted and separated (3-4 weeks). Non-vaccinated HCW should not care for patient if immune HCW available.
Staphylococcal		
Major, wound	Contact	
Streptococcal		
Major, wound	Contact, droplet	

HCW = Health care workers ; HIV = human immunodeficiency virus; MDRO = multi-drug-resistant organisms MRSA = methicillin-resistant *Staphylococcus aureus*; PEP = post-exposure prophylaxis; VRE = vancomycin-resistant enterococci; VISA/VRSA = vancomycin-intermediate/resistant *S. aureus*; ESBL = extended-spectrum beta-lactamase producing organisms; SARS-CoV = severe acute respiratory syndrome associated corona virus.

* Adapted from *CDC Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Healthcare Settings 2007*. For a complete list of organisms see Appendix A. Type and duration of precautions recommended for selected infections and conditions.
<http://www.cdc.gov/ncidod/dhqp/pdf/guidelines/Isolation2007.pdf>

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C. Bloodborne Pathogens (HBV, HCV, HIV)

i. Recommendation

- Unless otherwise contraindicated, all anesthesiologists should be vaccinated and have documented immunity to hepatitis B virus (HBV).
- Strict adherence to standard precautions and sharps safety is required at all times.
- Should an exposure incident occur, immediate evaluation for postexposure prophylaxis (PEP) and follow-up care should be sought.

ii. Rationale

1. HBV

As of 2006, CDC data estimates the number of individuals chronically infected with HBV is 1.25 million persons.¹ The risk of infection after an exposure varies with viral titer, volume, and site of exposure. Transmission may occur via percutaneous injury, mucous membrane exposure, or contact with non-intact skin. With a sharps injury, larger quantities of blood are transmitted when the device is visibly contaminated with blood, the needle was previously in the vasculature of the source patient (esp. hollow bore needles), and when a deep injury is sustained. When a sharp injury occurs through a glove, the amount of blood on the external surface of the device may be reduced by 46% to 86%.² It should be noted that transmission might also occur through contact with contaminated environmental surfaces. HBV has been found to remain infective on environmental surfaces for over 7 days.³

Body fluids that have titers that may result in transmission are blood, semen, vaginal secretions, cerebrospinal fluid (CSF), synovial fluid, pleural fluid, peritoneal fluid, and amniotic fluid. Those that have a titer too low to pose a significant risk of transmission, unless contaminated with blood, are feces, nasal secretions, saliva, sputum, sweat, tears, urine, and vomitus. Blood has a 100- to 1,000-fold higher titer than these other fluids.²

The risk of seroconversion to HBV after a percutaneous injury with source blood that is HBsAg positive is 22% to 31%. For blood that is HBeAg or pre-core mutant positive, the risk is 37% to 62%. The presence of HBeAg and the pre-core mutant are correlated with active viral replication and infectivity.²

The prevalence of HBV infection among HCWs was 10-fold higher prior to the recommendation in the early 1980s that all healthcare workers (HCWs) with a risk of exposure to bloodborne pathogens be vaccinated against HBV. The seroprevalence among HCWs is now no higher than that of the general population. The vaccine is given in a series of 3 intramuscular injections in the deltoid. The second dose should be given 1 month and the third 6 months after the first dose. Serologic testing for evidence of conversion should be performed 1 to 2 months after the third dose. Non-responders to the first series have a 30% to 50% chance of responding to a second series.²

Anyone without a documented adequate response to the HBV vaccine series should receive PEP after a significant exposure. PEP includes 1 to 2 doses of human immune globulin (HBIG) with or without the HBV vaccine. For current recommendations, refer to:

http://www.nccc.ucsf.edu/Clinical_Resources/PEPGuidelines.html

<http://www.cdc.gov/hiv/resources/guidelines/index.htm>

2. HCV

In 2006, an estimated 3.2 million people in the United States had chronic hepatitis C virus (HCV) infection. The modes of transmission for HCV are the same as those for HBV. Ex vivo survival

of HCV is not well defined, but is shorter than for HBV, with infectivity declining within hours on environmental surfaces. The risk of acquiring HCV after a percutaneous injury is 1.8% (range: 0%-7%).² More recent data estimate this risk at 0.3% to 0.74%.⁴⁻⁶

After HCV seroconversion, only 15% to 25% will clear the virus spontaneously. Of those who develop chronic hepatitis, 20% will develop cirrhosis over the following 20 to 30 years and 1% to 2% of those will be diagnosed with hepatocellular carcinoma.⁷

Although at this time no specific PEP has been documented to be effective for HCV, it is recommended that evaluation be sought after HCV exposures to assess baseline liver function and determine treatment options should seroconversion occur. Some promising treatment regimens for acute infection have resulted in a sustained virologic response (absence of detectable HCV RNA 6 months after completion of treatment). A combination of interferon and ribavirin are given for 48 months.³

3. HIV

The CDC estimates that in 2003 between 1,039,000 and 1,185,000 people were living with human immunodeficiency virus (HIV) in United States and 56,300 new infections occurred each year.⁸ Modes of transmission for HIV are the same as those for HBV and HCV. The risk of conversion from a percutaneous HIV exposure is 0.3%, while the risk of a mucous membrane exposure is 0.09%. HIV viral titers vary with the stage of disease and treatment. Viral titers are highest during the viremic period of acute infection, and with advanced disease. Rates of seroconversion are directly proportional to the viral load.⁹

The efficacy of PEP for HIV infection is based on viral pathogenesis. In the first 24 hours after exposure, HIV infects local dendritic-like cells, after which the virus migrates to regional lymph nodes where they are detectible after 24 to 48 hours. Virus is detectible in peripheral blood within 5 days. Data available on PEP include animal (difficult to directly generalize results to humans), human (small number of cases and controls from a different cohort), and human vertical transmission. The decrease in seroconversion after PEP is estimated to be from 50% to 81%.^{2,5,10}

The treatment of HIV includes 5 classes of drugs: nucleoside reverse transcriptase inhibitors (NRTIs), nucleotide reverse transcriptase inhibitors (NtRTIs), non-nucleoside reverse transcriptase inhibitors (NNRTIs), protease inhibitors (PIs), and single fusion inhibitors. PEP is complex and has evolved over time. A 2-drug regimen taken for 4 weeks is generally recommended for PEP. Evidence suggests that standard PEP may be less effective when the source patient viral strain shows antimicrobial resistance. However, because it takes 1 to 2 weeks to carry out resistance testing, it generally does not influence initial PEP. For the latest recommendations, refer to <http://www.cdc.gov/hiv/resources/guidelines/index.htm>
http://www.nccc.ucsf.edu/hiv_clinical_resources/pep_guidelines/

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D. Tuberculosis

i. Tuberculosis (TB): General Information

Mycobacterium tuberculosis (MTB) is an aerobic rod measuring 2 to 4 μm by 0.3 μm that thrives at a pO_2 of 140 mm Hg. The bacilli are released into the air as droplets when a person vocalizes, sneezes, or coughs. Droplet-sized particles ($>5\text{-}10\ \mu\text{m}$) are typically dispersed within a 3-foot radius. If they are inhaled, they are trapped and cleared by the cilia of the upper airway. As the droplets desiccate and become droplet nuclei, they can be carried long distances on air currents. When inhaled, particles of this size ($<5\ \mu\text{m}$) penetrate deep into the bronchioles, thereby leading to infection. The highest risk period for developing active disease is in the first 1 to 2 years after exposure, with a lifetime risk of 10%. Individuals who are immunocompromised have a 10% risk per year of developing active TB. Typical signs and symptoms of active disease are cough (74%), weight loss (71%), fever (30%), malaise (30%), and hemoptysis (19%).¹

After centuries of being an incurable disease, the first treatment for TB, streptomycin, was discovered in 1944. However, it was soon realized that MTB rapidly develops resistance when monotherapy is used. Between 1949 and 1963, the drugs that remain first-line agents in the treatment of TB were discovered and worldwide eradication of the disease was anticipated. In the late 1980s, however, the disease saw a worldwide resurgence. Although the rates have been declining since 1993, the most recent World Health Organization (WHO) statistics on the global TB burden are as follows:

- Incidence of 8.9 million
- Prevalence of 14.6 million
- Yearly mortality of nearly 1.7 million people
- 1/3 of the world population has been exposed²

The incidence of TB in the United States is 4.2 in 100,000 persons, with 12,904 new cases reported in 2008 (a decrease of 2.9% from 2007, and 54% from 1980). The emergence of drug resistant strains is worrisome. Multi-drug resistance (MDR-TB), defined as resistance to at least isoniazid (INH) and rifampin, accounts for 1.0% of reported cases. In 2007, 2 cases of extensively drug-resistant TB (XDR-TB) were seen, down from 4 cases in 2006. From 1993 to 2007, 51 cases of XDR-TB were reported in the United States. XDR-TB is resistant to INH, rifampin, fluoroquinolones and at least 1 of 3 injectable second-line agents (amikacin, kanamycin, capreomycin). Currently, only 30% of XDR-TB is curable.³⁻⁹

ii. Elective Surgery for Patients with Active TB Infection

1. Recommendation

Elective operative procedures on patients with active pulmonary or laryngeal TB should be postponed until the patient is no longer infectious.

2. Rationale

The risk of transmission is significant, and the cost associated with the perioperative care of a patient with an airborne infectious disease is increased, which is not warranted for elective

procedures. The risk of infectivity is minimal once the criteria for the discontinuation of isolation precautions are met. These criteria include (1) an alternative diagnosis that explains the clinical syndrome, (2) the patient is responding to treatment, and (3) the patient has 3 negative AFB sputum smears. Sputum specimens should be collected 8 to 24 hours apart and at least 1 should be an early morning sample as there is a higher sensitivity for pooled secretions from overnight.¹⁰

iii. Urgent/Emergent Surgery for Patients with Active TB Infection

1. Recommendation

For urgent and emergent procedures that must be performed on patients with diagnosed or suspected TB, measures must be taken to minimize the exposure of other patients and health care workers (HCWs) who are in the operating room suites. (See “Transmission-Based Precautions: Airborne Precautions.”)

2. Rationale

Operating rooms are designed to provide positive pressure in relation to the surrounding corridors to minimize the risk of surgical site infections from non-sterile areas. This poses a risk of spreading airborne infectious diseases throughout the operating room (OR) suite. Considerations in selecting the most appropriate OR include the presence of the fewest patients and personnel; OR with highest number of air exchanges per hour (ACH), preferably >12; an OR with an antechamber that is either positive pressure in relation to both the OR and surrounding corridors, or negative pressure in relation to both.¹ Commercially available portable negative pressure containment units with high-efficiency particulate air (HEPA) filtration may be considered to transform an OR into an airborne isolation room.

iv. Respiratory Protective Devices for HCWs

1. Recommendation

A valve-less N95 (or higher protection factor) mask should be used to protect the HCW from breathing droplet nuclei and to protect the surgical field from respiratory contamination.

2. Rationale

Respirators certified by the National Institute for Occupational Safety and Health (NIOSH) meet minimum filter efficiency standards for protection against respiratory pathogens. During normal tidal volume ventilation, the N95 mask filters 95% of 0.3- μm particles (considered to be the most highly penetrating). Individuals must be fit-tested to determine the appropriate size and brand. An improperly fitted mask that does not seal to the user’s face will result in the inhalation of unfiltered air around the edge of the mask that has not been filtered. Fit testing should be repeated yearly and if the individual has a significant change in facial features. A seal check should be performed every time an N95 mask is donned. A properly fitting mask will draw in slightly when making a rapid inspiratory effort. Individuals who care for patients with airborne infectious diseases who cannot be properly fit tested must use a higher level of protection (e.g., powered air purifying respirator- PAPR).

v. Use of Filters on the Anesthesia Breathing Circuit

1. Recommendation

A bacterial filter with an efficiency rating of >95% for particle sizes of 0.3 μm should be routinely placed in the anesthesia circuit where it will protect the machine from contamination with airborne infectious diseases.

2. Rationale

As with bloodborne pathogens, it is often only in retrospect that we learn that a patient has a respiratory infectious disease. Experimental studies have shown that many respiratory pathogens, including MTB, which are nebulized into the expiratory limb of the anesthesia circuit, can be recovered and cultured from the inspiratory limb of the circuit.¹¹

vi. Recovery From Anesthesia

1. Recommendation

If possible, the patient should recover in a respiratory isolation room. Recovering in the OR where the procedure took place is an alternative. The same level of respiratory protection should be continued during recovery.

2. Rationale

Most institutions will not have airborne isolation capability in the post anesthesia care unit. The OR should be kept vacant until a 99.9% turnover of the air has occurred. Time will vary with the ACH for individual ORs (Table 1).

vii. TB Screening Programs for HCWs

1. Recommendation

Anesthesia personnel should have a baseline screening and yearly testing for exposure to MTB. Baseline screening consists of a tuberculin skin test (TST) or a QuantiFERON®-TB Gold (QFT-G) blood test. A 2-step TST is used for screening when there is no prior documentation of TST for those who will require periodic testing. An initial skin test may be paradoxically negative if cellular immunity has waned. A second test, 1 to 3 weeks after the first, allows time for a boosted immune response, thereby improving the sensitivity of the test. Individuals with a positive TST require chest radiography, and a review of symptoms is used for future screening. The QFT-G test exposes whole blood to MTB antigens and measures the interferon-gamma released from the white blood cells. Because the antigens are specific to MTB, the test can differentiate between exposure to MTB, other mycobacterium species, and prior vaccination with Bacillus Calmette-Guerin (BCG). Personnel who have been exposed to TB should be screened shortly after the exposure and again in 12 weeks to test for conversion.

2. Rationale

Anesthesia personnel are at medium risk for exposure according to the CDC classification in the Guidelines for Preventing the Transmission of *Mycobacterium tuberculosis* in Health-Care Settings, 2005, and are therefore required to comply with screening recommendations.

viii. Treatment of TB

1. Recommendation

Prophylaxis for latent TB infection should be considered for anyone who tests positive for exposure to TB, especially for recent conversion and those in a higher risk group for progressing to active disease.

HCWs with active disease may not work until they are no longer infectious.

2. Rationale

The risk of progression from latent TB infection (LTBI) to active TB depends on many factors: duration since conversion, age, and co-existing disease. In some populations, the risk may be 20% or more. Prophylaxis for LTBI is estimated to be 69% to 93% effective in preventing progression.^{12,13} Treatment protocols may be found at:

<http://www.cdc.gov/MMWR/preview/MMWRhtml/rr5211a1.htm>

TABLE 1. Air changes per hour (ACH) and time required for removal efficiencies of 99% and 99.9% of airborne contaminants*

ACH	Minutes required for removal efficiency†	
	99%	99.9%
2	138	207
4	69	104
6	46	69
12	23	35
15	18	28
20	7	14
50	3	6
400	<1	1

* This table can be used to estimate the time necessary to clear the air of airborne *Mycobacterium tuberculosis* after the source patient leaves the area or when aerosol-producing procedures are complete.

† Time in minutes to reduce the airborne concentration by 99% or 99.9%.

Table: Air Changes per hour (ACH) and Time Required for Removal Efficiencies of 99% and 99.9% of Airborne Contaminants*

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* This Table can be used to estimate the time necessary to clear the air of airborne *Mycobacterium tuberculosis* after the source patient leaves the area or when aerosol-producing procedures are complete.

† Time in minutes to reduce the airborne concentration by 99% or 99.9%.

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E. Emerging Infectious Diseases/Pandemic Influenza

i. Background

An emerging infectious disease (i.e., one that has not been previously identified) may arise from either a newly discovered pathogen or a new strain of a known pathogen. Consequently, it is antigenically novel to humans. Factors contributing to emergence and spread of disease in humans are an ever-increasing world population, human incursion into areas harboring the natural reservoirs of these diseases, globalization (travel, trade), climatic change, and insufficient public health resources to provide an effective global public health infrastructure.^{1,2}

A novel influenza virus (H1N1) was identified in persons from Mexico and the United States in April 2009. On June 11, 2009, the World Health Organization (WHO) declared the disease pandemic when 70 countries reported cases. A pandemic designation indicates only the prevalence, but not the virulence, of a disease. The confirmed cases that the CDC has reported in the United States as of February 2010, were 50,240 hospitalizations and 2,435 deaths.³ However, as of mid-December 2009, the CDC estimated that 40 to 80 million people had been infected with the virus. Worldwide, over the first 6 months since the identification of this virus, nearly 350,000 cases and 4,180 deaths have been confirmed.⁴ The total number of cases is a significant underestimation because this number reflects only confirmed cases. The overall severity of illness has been consistent with that seen with seasonal influenza, which yearly hospitalizes 200,000 and causes 36,000 fatalities in the United States. Unlike seasonal flu, however, the lowest attack rate for H1N1 has been in those older than 60 years, 1/3 of whom have been shown to have partial immunity to the virus.⁵ This is consistent with the finding that this virus is a quadruple reassortment virus (Eurasian and North American swine, avian, and human lineages) possessing genes to which older individuals may have had previous exposure.⁶ The CDC and the WHO continue to monitor the virus for evidence of changing pathogenicity. An inactivated and a live attenuated influenza vaccine (LAIV) have been developed against the H1N1 virus.

Of ongoing concern is the avian influenza virus H5N1. It is being closely tracked as a possible precursor to a pandemic influenza virus. The first known human cases occurred in Hong Kong in 1997. Eighteen cases were identified, 6 of whom died. As of January 28, 2010, the WHO reports 471 human cases of H5N1 with 282 fatalities (59.9%).⁷ Human cases have occurred in 15 countries across Asia, Africa, and the Middle East. Infection in domestic and wild bird populations has now extended into parts of Europe. Although the disease is currently almost exclusively spread to humans via contact with infected domestic birds, the CDC has identified at least 2 clusters in which direct human-to-human transmission appears to have occurred.⁸ This corresponds to Phase 3 of the WHO's 6-phase classification of pandemics (human infection(s) with a new viral strain, but with rare or no human-to-human spread).⁹ The H5N1 viral sequence has been compared with that of the 1918 pandemic influenza virus (H1N1). Genetic sequences responsible for infectivity, virulence, and human-to-human transmission have been investigated. It is thought that the H5N1 contains 5 of the 10 genetic sequences responsible for direct human-to-human transmission of the 1918 virus.¹⁰

ii. Recommendations

Limit contact of infected and non-infected individuals through effective triage, isolation precautions, and spatial separation (>3 feet). Standard precautions and proper hand hygiene should be used at all times. Adhere to recommended precautions for all modes of disease transmission (contact, droplet, airborne). Hospitalized patients with suspected or confirmed novel

influenza viruses should be placed in a private room and the door kept closed. Patients should remain in isolation except during medically necessary procedures. When out of respiratory isolation, patients should wear a standard surgical mask, which is sufficient to trap expelled droplets. All healthcare workers should be vaccinated against H1N1 and seasonal influenza.

Personal protective equipment should be worn for all contact (in the patient's room, during close contact, aerosol-generating procedures should be performed in an airborne infection isolation room) with patients infected with pandemic influenza. This includes:

- Respirators: Disposable, fit-tested N95 or greater respiratory protection.
- Eye protection, disposable gowns, and gloves

Hand hygiene should be performed before and after contact with a patient and upon removal of gloves. Avoid contact contamination by touching eyes, nose, mouth, and skin with contaminated hands. Encourage respiratory etiquette/cough hygiene. Use dedicated patient equipment whenever possible.¹¹⁻¹⁶

1. Operating room

Patients should be brought to the OR for urgent or emergent cases only. Efforts should be made to limit exposure of personnel and patients. This may include performing the surgery when the fewest people are present, limiting the personnel involved in the case, and choosing an operating suite remote from others. All unnecessary equipment should be removed from the room to avoid possible contamination. Full PPE should be used. Bacterial/viral filters should be used on the anesthesia circuit to prevent exposure of the machine to respiratory pathogens. Recovery of the patient should be in isolation. PPE should be disposed of upon leaving the OR and clean PPE donned for transport. The anesthesia circuit and gas sampling line should be disposed of at the conclusion of the case. All surfaces should be disinfected with an agent approved by the Environmental Protection Agency (EPA).^{14,17-21}

iii. Rationale

Infection control recommendations are typically based on the mode of transmission of the infectious agent. However, under the following circumstances, the CDC recommends enhanced precautions (additional work practices):

- There is a high risk of serious disease or mortality.
- With novel viruses, each human infection carries a risk that the organism will undergo further genetic evolution/shift resulting in a more virulent strain or, in the case of avian influenza, enabling it to transmit more effectively from human to human, allowing for the emergence of a pandemic strain.²²

H1N1 is transmitted via droplet and direct/indirect contact with respiratory secretions as with seasonal influenza. Enhanced precautions are being recommended for this virus, as its evolution at this time is uncertain.

The currently circulating strains of avian influenza are transmitted through direct contact with infected birds (secretions, excretions, blood, inadequately cooked meat). If/when an avian influenza virus develops the capacity to be efficiently transmitted between humans, it is unknown whether it will be through direct contact, droplets, or airborne transmission mechanisms. There is some Evidence that the H5N1 virus has a higher affinity for receptors in the distal airways than seasonal influenza viruses.^{23,24} This may explain the relatively uncommon transmission of

currently circulating H5N1 viruses as well as the rare human-to-human transmission that the CDC has reported to date (possibly 2 self-limited clusters).²⁵ Because of the uncertainty regarding the transmission mechanism that will predominate if the virus develops pandemic capacity, enhanced infection control practices (for all modes of transmission) are currently being recommended. In addition, every human infection creates an opportunity for all viruses to adapt to a human host.⁷ Vaccination can prevent the disease in an individual, decrease the risk of simultaneous infection that could lead to a reassortment event, and limit host availability for infection to propagate.

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F. PPE: Respirators for the Care of Patients with Virulent Respiratory Pathogens

i. Background

In addition to multi-drug resistant (MDR) and extremely drug resistant TB (XDR-TB), other virulent life-threatening pathogens such as SARS-CoV (Severe Acute Respiratory Syndrome-Coronavirus), H1N1 2009 pandemic influenza, H5N1 avian influenza, smallpox, and polio present an extreme and sometimes immediate health threat to anesthesia and critical care providers. This risk extends to their families, colleagues, and other patients through secondary contact.

ii. Recommendations

A fit-tested N95 respirator is the minimum respiratory protection recommended by the CDC and Occupational Safety and Health Administration (OSHA) during close contact with patients with highly pathogenic respiratory illnesses, including TB, SARS, and pandemic influenza.^{1,2} In addition, full contact precautions consisting of hat, gown, gloves, goggles or face shield, and shoe covers are indicated for SARS, pandemic influenza, and other diseases transmitted by both contact and respiratory modes. Those involved in invasive airway procedures and other therapeutic modalities that generate aerosols may consider using a higher level of respiratory protection, the powered air purifying respirator (PAPR).¹

iii. Rationale

OSHA identifies anesthesia providers as being at high risk of exposure to respiratory infectious disease during invasive airway procedures.²

High-risk aerosol exposure:

- Aerosol particles have been found to be infective at a 100-fold lower dose than nasally administered drops.³
- Anesthesia and critical care providers are at an increased risk of acquiring contagious respiratory disease when working in close proximity to aerosols (endotracheal intubation/extubation) or during “aerosol generating procedures,”^{1,2} including high-flow oxygen delivery, administration of aerosolized and nebulized medications, diagnostic sputum induction, bronchoscopy, open airway suctioning, bag-mask positive-pressure ventilation, non-invasive ventilatory methods (e.g., bilevel positive airway pressure [BiPAP], continuous positive airway pressure [CPAP]), and high-frequency oscillatory ventilation.^{1,2}
- Spontaneous coughing and sneezing also generates aerosol.⁴

iv. Devices that Reduce Exposure to Respiratory Pathogens (Respirators)

The devices available for respiratory protection in the health care venue include disposable N95 (or N100) respirators, non-disposable elastomeric respirators, PAPRs, and fluid-resistant surgical masks. Questions persist with respect to the most appropriate level of respiratory protection during close contact, or aerosol-generating procedures in patients with infectious respiratory disease.^{1,5,6}

1. N95 respirator

The N95 filtering face piece respirator inhibits passage of 95% of 0.3-micron test particles. In clinical settings, protection depends on achieving and maintaining a tight face seal. Fit testing is required to determine the most suitable model and size for the wearer. However, the fit test does not ensure that the wearer will consistently be able to achieve a face seal at the time of use.⁷ The N95 is associated with additional disadvantages: increased resistance to breathing⁸ and an inability for those with facial hair to achieve a mask seal.

Exposure to pathogens while wearing an N95 respirator is probably not as a result of inadequate particle filtration, but secondary to unfiltered air leakage around the sides (inadequate seal) or from self-contamination while removing or reusing the respirator.

OSHA urges institutions to stockpile protective equipment and supplies prior to periods of high demand and limited resources.^{9,10} Huge quantities of N95s are required during a pandemic, and supplies may be rapidly depleted. Non-disposable elastomeric tight-fitting respirators (silicone or rubber masks with a filter) are an alternative to the N95.¹

The reuse of N95 respirators is discouraged but may be necessary if supplies are insufficient for single use.¹ Under such circumstances, the CDC recommends instituting procedures for the reuse and storage of N95s rather than using surgical masks as a substitute. However, no statistically significant difference was found in the incidence of influenza among nurses wearing either surgical masks or N95 masks. Both groups had a 20% infection rate.⁵ However, seasonal influenza is spread by droplet and contact modes of transmission. When reusing an N95 mask, it should be stored in a manner that prevents the accumulation of moisture as this will compromise its effectiveness. N95 mask allocation should be prioritized to those at highest risk of exposure. Surgical masks may be used when N95s are unavailable, however, the CDC emphasizes that the surgical mask is not appropriate for protection for those performing or participating in aerosol-generating procedures.¹

2. The PAPR

The PAPR provides a higher level of protection than the N95. The CDC and OSHA both state that a higher level of respiratory protection may be considered, but is not mandatory, for health care personnel performing aerosol-generating procedures on patients with virulent respiratory diseases.^{1,2}

- Assigned protection factor (APF): The APF refers to the amount of protection afforded by a respirator beyond wearing no respirator at all. The N95 has an APF of 10. That is, it supplies 10 times the protection relative to ambient air. The PAPR, using a full hood that covers the head and shoulders, has an APF of 1,000.¹¹ An alternative hood, the loose fitting face cover, has an APF of 25.
- Description of a PAPR: A PAPR consists of a battery-powered non-disposable blower and filter unit worn on a waist belt. The blower draws air at 6 cu ft/min or 170 L/min through a high-efficiency particulate air (HEPA) filter. The filtered air passes through a corrugated tube into the back of a disposable or reusable hood and prevents the wearer from entraining contaminated room air by creating a positive flow from inside to outside the hood.^{12,13} Manufacturers of PAPRs are 3M, Bullard, MSA, and North Safety.

Issues associated with deploying the PAPR: In addition to offering a higher level of protection, the PAPR has several advantages over the N95. However, complexities of use, training, maintenance, and storage require attention prior to deploying the respirator in the clinical setting.⁸ Anesthesia departments are strongly advised to address PPE issues in advance of clinical need.^{2,14}

Risk of self-inoculation from contaminated protective equipment: Although the PAPR hood supplies full contact protection for the head and neck, it should be appreciated that both contaminated exposed skin and contaminated PPE may be a source of contact transmission and self-inoculation.^{15,16} To avoid infection through self-contamination, don and doff sequence must be meticulously adhered to.¹⁷ Training and practice contribute to provider and patient safety. Respirator removal must be followed by conscientious hand washing and other recommended infection control precautions. Work garb should never be worn outside the health care environment. All don and doff, reprocessing, and usage procedures should be approved by a hospital infection control practitioner.

PAPR use during surgery contraindicated: A major unresolved dilemma exists regarding use of the PAPR during surgery. Instruction from the manufacturer 3M™ instructions and the OSHA Pandemic Influenza Preparedness and Response Guidelines for Healthcare Workers and Healthcare Employers,² state that because the PAPR is positive pressure in relation to the environment, its use in the OR is contraindicated because of an increased risk of wound infection.

To accommodate this directive, endotracheal intubation and extubation could be done in a separate room. Alternatively, if intubation must be done in the OR the sterile fields could be covered while the PAPR is in use. Other aerosol-generating procedures occurring after surgical incision, such as open suctioning, nebulization of medications, or bronchoscopy, would require redonning the PAPR and covering the operative field with a barrier while the PAPR is in use.

The prohibition of using the PAPR in the OR does not distinguish between hood types. Some institutions may permit the use of the PAPR with a full hood, because with this device the air exits below the level of the surgical field, whereas in others the air exits from the loose fitting face cover underneath the chin of the wearer and could flow directly over the surgical field. A definitive solution needs to be investigated so that a device with this level of respiratory protection is available in the OR.

- OSHA-compliant respiratory protection program: For all industrial and medical respiratory protection systems, OSHA requires that the employer deploys the respirators within the context of a respiratory protection program (RPP), some components of which are a RPP director, written protocols, medical clearance of the PPE wearer, training and at least yearly fit testing or practice.²
- PAPR training workshop: Training materials and user instructions are available on the manufacturers' Websites. The didactic component of a PAPR training workshop may supplement the manufacturers' material and is available to use as a component of an OSHA-compliant respiratory protection program.^{18,19}

3. PPE for Treating Victims of Exposure to Hazardous Materials:

“Medical PAPRs”, or PAPRs used for infectious disease protection are biologic particulate filters, and will not provide protection when caring for victims of chemical exposure. “Chemical PAPRs” contain an absorbent cartridge for chemicals instead of a HEPA filter, and the hood is made of chemical-resistant butyl rubber. A dual-purpose cartridge can be used with the chemical but not the medical PAPR. Manufacturers can provide training materials and technical assistance with questions on use and maintenance of both types of PAPRs.

OSHA requires that all workers who anticipate caring for contaminated victims of hazardous material exposure receive 8 hours of awareness (informational) and operations level (practical) training.²⁰

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IV. GLOSSARY

Robin A. Stackhouse, M.D.

Airborne infection isolation room (AIIR).

- Room is negative pressure in relation to adjoining spaces. Door must be kept shut to maintain negative pressure.
- 6-12 air exchanges per hour (ACH). 6 ACH for existing structures, 12 ACH for new construction.
- Air exhausted directly to the outside (away from trafficked areas) or recirculated through a HEPA filter.

Contact precautions. Practices used to prevent the transmission of infectious agents by direct or indirect contact. These precautions are applied in the presence of specific pathogens (MRSA, VRE, *C. difficile*, etc.), or in situations in which there is an increased risk of transmission of infectious agents (draining wounds, fecal incontinence, or other discharges).

- Single patient room preferred. When this is not possible, options include cohorting of patients with the same infectious agent, keeping the patient with the existing roommate, maintaining ≥ 3 feet of separation between patient beds.
- Wear gown and gloves when caring for patients on contact precautions.
- Perform hand hygiene after removing gown and/or gloves.
- Minimize sharing of equipment.

Critical devices. Items that contact normally sterile tissues and are associated with a high risk of infection if contaminated with microorganisms. Items should be sterile at the time of use.

Droplet nuclei. Particles that are $< 5 \mu\text{m}$ that result from the dehydration of droplets that are routinely generated from coughing, sneezing, shouting, or singing. The particles can remain airborne and travel long distances on air currents.

Hand hygiene. Hand cleaning with soap (non-antimicrobial) and water, antiseptic handwash, antiseptic handrub, or surgical hand antisepsis.

High-efficiency particulate air (HEPA) filter. A filter that removes $> 99.97\%$ of particles that are $\geq 0.3 \mu\text{m}$ in size (the most penetrating particle size) at a specified flow rate.

High-level disinfection. Destroys all microorganisms except high levels of spores.

Intermediate-level disinfection. Destroys vegetative bacteria, most viruses, and fungi but not spores.

Low-level disinfection. Destroys bacteria, some viruses, and some fungi, but not spores.

Multi-drug-resistant organisms (MDROs). Bacteria that are resistant to 1 or more classes of antibiotics.

Non-critical devices. Items that will only contact intact skin. Intermediate or low-level disinfection adequate.

Powered air purifying respirator (PAPR). A battery-powered half or full face piece mask or hood that delivers HEPA-filtered air to the wearer.

Post-exposure prophylaxis (PEP). Medication that is given to health care workers after they have had a known exposure to a bloodborne pathogen.

Personal protective equipment (PPE). Gloves, masks, respirators, goggles, face shields, gowns. Used as barriers to protect the skin, mucous membranes, and clothing from infectious agents.

Respirator. National Institute for Occupational Safety and Health (NIOSH)–certified face mask to protect against airborne infectious diseases of particle size $<5 \mu\text{m}$. N95 masks have a filter efficiency of $\geq 95\%$.

Respiratory hygiene/cough etiquette. Applies to anyone with cough, congestion, rhinorrhea, or increased production of respiratory secretions.

- Covering mouth and nose when coughing or sneezing.
- Contain respiratory secretions with tissue, and dispose promptly and appropriately.
- Use of a surgical mask by anyone who is coughing or sneezing.
- Maintaining ≥ 3 feet of separation and turning away from others when coughing.
- Perform and encourage others to practice hand hygiene after contact with respiratory secretions.
- HCWs encouraged to use droplet precautions in the presence of a patient with signs or symptoms of a respiratory infection.

Standard precautions. Precautions that are derived from, and are an expansion of what were formerly what were formerly Universal Precautions and Body Substance Precautions. They should be applied during all patient care. All blood, body fluids, secretions (except sweat), non-intact skin, and mucous membranes must be assumed to be contaminated with infectious agents.

- Hand hygiene.
- Appropriate use of PPE.
- Appropriate handling/cleaning of contaminated objects.

Semi-critical devices. Items that contact mucous membranes and non-intact skin. These require a minimum of high-level disinfection.

Sterilization. Destroys all microorganisms including bacterial spores.

Resources

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