

Guidelines for the Prevention of Intravascular Catheter-related Infections: Recommendations Relevant to Interventional Radiology for Venous Catheter Placement and Maintenance

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ABBREVIATIONS

BSI = bloodstream infection, CDC = Centers for Disease Control, CLABSI = central line-associated bloodstream infection, CRBSI = catheter-related bloodstream infection, CVC = central venous catheter, ICU = intensive care unit, MSB = maximum sterile barrier, PICC = peripherally inserted central catheter

INTRODUCTION

In the United States, 80,000 catheter-related bloodstream infections (CRBSIs) occur in intensive care units (ICUs) each year (1), and a total of 250,000 cases of CRBSIs have been estimated to occur annually if entire hospitals are assessed (2). In the ICU, these infections independently increase hospital costs and length of stay (3), but have not generally been shown to independently increase mortality.

The second edition of the Centers for Disease Control (CDC) Guidelines for the Prevention of Intravascular Catheter-related Infections was published on August 9, 2002, in the Reports and Recommendations series of the Morbidity and Mortality Weekly Report (4), and replaced the original guideline published in 1996. The goal was to provide evidence-based recommendations for preventing catheter-related infections. Selected recommendations from the 2002 guideline relevant to interventional radiology were excerpted as a Society of Interventional Radiology (SIR) guideline published in the *Journal of Vascular and Interventional Radiology* in 2003 (5,6).

Major areas of emphasis in the 2002 CDC Guidelines included (i) educating and training health care providers who insert and maintain catheters, (ii) using maximum sterile barrier (MSB) precautions during central venous catheter (CVC) insertion, (iii) using a 2% chlorhexidine preparation for skin antisepsis, (iv) avoiding routine replacement of CVCs

as a strategy to prevention of infection, and (v) using antiseptic/antibiotic agent-impregnated short-term CVCs and chlorhexidine-impregnated sponge dressings if the rate of infection is high despite adherence to other strategies (ie, education and training, MSB precautions, and 2% chlorhexidine for skin antisepsis).

Unfortunately, implementation of evidence-based CRBSI preventive practices in US hospitals has been suboptimal (3). In a national survey conducted in March 2005 of more than 700 US hospitals, approximately one quarter of hospitals indicated that (i) MSB precautions during central catheter insertion and (ii) chlorhexidine gluconate as site disinfectant, two practices widely recommended in the 2002 guidelines, were not being used routinely (7). Approximately 15% of US hospitals reported routinely changing CVCs to prevent infection despite evidence that this practice should no longer be used (3,7).

The 2002 CDC guideline has now been revised and updated. The new document, published in 2011 (8), was prepared by a working group comprising members from professional organizations representing the disciplines of critical care medicine, infectious diseases, health care infection control, surgery, anesthesiology, interventional radiology, pulmonary medicine, pediatric medicine, and nursing. The working group was led by the Society of Critical Care Medicine, in collaboration with the Infectious Disease Society of America, Society for Healthcare Epidemiology of America, Surgical Infection Society, American College of Chest Physicians, American Thoracic Society, American Society of Critical Care Anesthesiologists, Association for Professionals in Infection Control and Epidemiology, Infusion Nurses Society, Oncology Nursing Society, American Society for Parenteral and Enteral Nutrition, the Society of Interventional Radiology, American Academy of Pediatrics, Pediatric Infectious Diseases Society, and the Healthcare Infection Control Practices Advisory Committee of the CDC.

The 83-page electronic version of the 2011 CDC guideline is available online without charge (<http://www.cdc.gov/hicpac/pdf/guidelines/bsi-guidelines-2011.pdf>). Major areas of emphasis in the 2011 guideline include (i) educating and training health care personnel who insert and maintain catheters, (ii) using MSB precautions during CVC insertion, (iii) using a greater than 0.5% chlorhexidine skin preparation with alcohol for antisepsis, (iv) avoiding routine replacement of CVCs as a strategy to prevent infection, and (v) using antiseptic/antibiotic agent-impregnated short-term CVCs and chlorhexidine-impregnated sponge dressings if the rate of infection is not decreasing despite adherence to other strategies (ie, education and training, MSB precautions, and > 0.5% chlorhexidine preparations with alcohol for skin antisepsis).

The CDC guideline is lengthy and includes recommendations regarding hand hygiene, peripheral venous catheters, umbilical catheters,

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peripheral arterial catheters, and replacement of administration sets and needleless intravascular catheter systems. These topics are not reviewed here. Portions of the new guideline are of particular interest to interventional radiologists, particularly those dealing with CVCs, peripherally inserted central catheters (PICCs), and hemodialysis catheters. This revised SIR guideline contains selected recommendations from the 2011 CDC guideline, presented verbatim, along with selected supporting data, background information, and references.

Definitions

Catheter-related Bloodstream Infection. Catheter-related bloodstream infection is a clinical definition used when diagnosing and treating patients. It requires specific laboratory testing to identify more thoroughly the catheter as the source of the bloodstream infection (BSI). It is often problematic to precisely establish if a BSI is a CRBSI as a result of the clinical needs of the patient (the catheter is not always removed), limited availability of microbiologic methods (many laboratories do not use quantitative blood cultures or differential time to positivity), and procedural compliance by direct care personnel (labeling must be accurate).

Central Line-associated BSI. "Central line-associated BSI" (CLABSI) is a term used by the CDC's National Healthcare Safety Network. A CLABSI is a primary BSI in a patient who had a central catheter within the 48-hour period before the development of the BSI, and is not related to an infection at another site. However, as some BSIs are secondary to other sources (other than the central catheter) that may not be easily recognized (eg, pancreatitis, mucositis), the CLABSI surveillance definition may overestimate the true incidence of CRBSI.

Midline Catheter. A midline catheter is a catheter inserted via the antecubital fossa into the proximal basilic or cephalic veins that does not enter the central veins.

Microbiology

The most commonly reported causative pathogens remain coagulase-negative staphylococci, *Staphylococcus aureus*, enterococci, and *Candida* species (9). Gram-negative bacilli accounted for 19% and 21% of CLABSIs reported to the CDC (10) and the Surveillance and Control of Pathogens of Epidemiological Importance database, respectively (9).

For all common pathogens causing CLABSIs, antimicrobial resistance is a problem, particularly in ICUs. Although methicillin-resistant *S. aureus* now account for more than 50% of all *S. aureus* isolates obtained in ICUs, the incidence of methicillin-resistant *S. aureus* CLABSIs has decreased in recent years, perhaps as a result of prevention efforts. For Gram-negative rods, antimicrobial resistance to third-generation cephalosporins among *Klebsiella pneumoniae* and *Escherichia coli* has increased significantly, as has imipenem and ceftazidime resistance among *Pseudomonas aeruginosa* (10). *Candida* species are increasingly noted to be fluconazole-resistant.

Pathogenesis

There are four recognized routes for contamination of catheters: (i) migration of skin organisms at the insertion site into the cutaneous catheter tract and along the surface of the catheter with colonization of the catheter tip (the most common route of infection for short-term catheters) (11,12), (ii) direct contamination of the catheter or catheter hub by contact with hands or contaminated fluids or devices (13), (iii) hematogenous seeding from another focus of infection (less common) (14), and (iv) infusate contamination (rare) (15).

Important pathogenic determinants of CRBSI are (i) characteristics of the device material; (ii) the host factors, consisting of protein adhesions such as fibrin and fibronectin, that form a sheath around the catheter (16); and (iii) the intrinsic virulence factors of the infecting organism, including the extracellular polymeric substance produced by the adherent organisms (17).

As a result of fibrin sheath formation, silastic catheters are associated with higher risk of catheter infections than polyurethane catheters (16). Biofilm formation by *Candida albicans* occurs more readily on silicone elastomer catheter surfaces than on polyurethane catheters (18). Modifi-

cation of the biomaterial surface properties has been shown to influence the ability of *C. albicans* to form biofilm. Some catheter materials have surface irregularities that enhance the microbial adherence of certain species (eg, *Staphylococcus epidermidis* and *C. albicans*) (18). Catheters made of these materials are particularly vulnerable to microbial colonization and subsequent infection. Additionally, certain catheter materials are more thrombogenic than others, a characteristic that might also predispose to catheter colonization and infection (19). This association has led to emphasis on preventing catheter-related thrombus as an additional mechanism for reducing CRBSI (20).

Host factors are also important in the pathogenesis of CRBSI, as they affect the adherence properties of a given microorganism. For example, *S. aureus* can adhere to host proteins (eg, fibrinogen, fibronectin) commonly present on catheters by expressing clumping factors that bind to the protein adhesins (16,19,21). Microbial adherence is also enhanced through the production, by microbial organisms such as coagulase-negative staphylococci (22), *S. aureus* (23), *P. aeruginosa* (24), and *Candida* species (25), of an extracellular polymeric substance that consists mostly of an exopolysaccharide that forms a microbial biofilm layer. This biofilm matrix is enriched by divalent metallic cations, such as calcium, magnesium, and iron, enabling microbial organisms to embed themselves (26). These biofilms potentiate the pathogenicity of various microbes by allowing them to withstand host defense mechanisms (eg, acting as a barrier to engulfment and killing by polymorphonuclear leukocytes) or by making them less susceptible to antimicrobial agents (eg, forming a matrix that binds antimicrobial agents before their contact with the organism cell wall or providing for a population of metabolically quiescent, antimicrobial tolerant "persister" cells) (22,27). In the presence of dextrose-containing fluids, some *Candida* species produce slime similar to that of their bacterial counterparts, potentially explaining the increased proportion of BSIs caused by fungal pathogens among patients receiving parenteral nutrition fluids (28).

CLASSIFICATION OF RECOMMENDATIONS

The 2011 CDC guideline contains a Summary of Recommendations with 99 specific recommendations. Each is categorized as category IA, category IB, category IC, category II, or unresolved issue (Table 1). The recommendations most relevant to the practice of interventional radiology are given as follows, with supporting information and references. Note that the organization and numbering used here differ from those used in the CDC guideline.

GENERAL RECOMMENDATIONS

General recommendations are provided in Table 2 (29–40).

A meta-analysis of 14 randomized, controlled trials evaluating the effects of prophylactic doses of heparin or heparin bonding on thrombus formation and infection associated with CVCs and pulmonary artery catheters found that heparin administration reduces thrombus formation and may reduce catheter-related infections in patients with these catheters (40). Heparin significantly decreases CVC-related thrombosis, decreases bacterial colonization of the catheter, and may decrease catheter-related bacteremia. To decrease the risk of major vessel thrombosis, unfractionated heparin must be administered in doses of at least 3 U/mL total parenteral nutrition, or 5,000 U every 6 hours or every 12 hours, and low molecular weight heparin must be administered in doses of at least 2,500 U subcutaneously daily. Lower doses may not be effective (40).

Catheter and Site Selection

Recommendations for catheter and site selection are provided in Table 3 (11,41–67).

The site at which a catheter is placed influences the subsequent risk for catheter-related infection and phlebitis. The influence of site on the risk for catheter infections is related in part to the risk for thrombophlebitis and in part on the density of local skin flora.

Table 1. Classification of Recommendations

Category	Description
IA	Strongly recommended for implementation and strongly supported by well-designed experimental, clinical, or epidemiologic studies
IB	Strongly recommended for implementation and supported by some experimental, clinical, or epidemiologic studies and a strong theoretical rationale; or an accepted practice (eg, aseptic technique) supported by limited evidence
IC	Required by state or federal regulations, rules, or standards
II	Suggested for implementation and supported by suggestive clinical or epidemiologic studies or a theoretical rationale
Unresolved issue	Represents an unresolved issue for which evidence is insufficient or no consensus regarding efficacy exists

Table 2. General Recommendations (29–36,38–40)

Recommendation	Category
Periodically assess knowledge of and adherence to guidelines for all personnel involved in the insertion and maintenance of intravascular catheters (29–34)	IA
Designate only trained personnel who demonstrate competence for the insertion and maintenance of peripheral and central intravascular catheters (33–36,38)	IA
Do not administer systemic antimicrobial prophylaxis routinely before insertion or during use of an intravascular catheter to prevent catheter colonization or CRBSI (39)	IB
Do not routinely use anticoagulant therapy to reduce the risk of catheter-related infection in general patient populations (40)	II

CRBSI = catheter-related bloodstream infection.

The density of skin flora at the catheter insertion site is a major risk factor for CRBSI. No single trial has satisfactorily compared infection rates for catheters placed in jugular, subclavian, and femoral veins. In retrospective observational studies, catheters inserted into an internal jugular vein have usually been associated with higher risk for colonization and/or CRBSI than those inserted into a subclavian vein (11,50–55). Similar findings were noted in neonates in a single retrospective study (68).

Femoral catheters have been demonstrated to have high colonization rates compared with subclavian and internal jugular sites when used in adults and, in some studies, higher rates of CLABSIs (54,55,57,58,69). Femoral catheters are also associated with a higher risk for deep vein thrombosis than are internal jugular or subclavian catheters (56,57,70). One study (50) found that the risk of infection associated with catheters placed in the femoral vein is accentuated in obese patients. In contrast to those in adults, studies in pediatric patients have demonstrated that femoral catheters have a low incidence of mechanical complications and might have an equivalent infection rate to that of nonfemoral catheters (71–74). Thus, in adult patients, a subclavian site is preferred for infection-control purposes, although other factors (eg, the potential for mechanical complications, risk for subclavian vein stenosis, and operator skill) should be considered when deciding where to place the catheter.

Catheters should be inserted at as great a distance as possible from open wounds. In one study (75), catheters inserted close to open burn wounds (ie, when the wound overlapped the 25-cm² area surrounding the catheter insertion site) were 1.79 times more likely to be colonized and 5.12 times more likely to be associated with bacteremia than catheters inserted further from the wounds.

Antimicrobial/Antiseptic Agent-impregnated Catheters and Cuffs

A recommendation regarding antimicrobial/antiseptic agent-impregnated catheters and cuffs is provided in **Table 3** (64–67).

Certain catheters that are coated or impregnated with antimicrobial or antiseptic agents can decrease the risk for CRBSI and could potentially

decrease hospital costs associated with treating CRBSIs, despite the higher prices of antimicrobial or antiseptic agent-impregnated catheters (67).

Nearly all studies involving antimicrobial/antiseptic agent-impregnated catheters have been conducted with the use of triple-lumen, uncuffed catheters in adult patients whose catheters remained in place for less than 30 days. These catheters have been approved by the US Food and Drug Administration for use in patients weighing more than 3 kg. Two nonrandomized studies in pediatric ICU patients (76) suggest that these catheters might reduce the risk of catheter-associated infection. No antiseptic or antimicrobial impregnated catheters currently are available for use in infants weighing less than 3 kg.

Two metaanalyses of catheters coated with chlorhexidine/silver sulfadiazine on the external luminal surface only (ie, first-generation catheters) demonstrated that these catheters reduced the risk for CRBSI compared with standard noncoated catheters (1,77). The duration of catheter placement in one study (78) ranged from 5.1 to 11.2 days. A second-generation catheter is now available with chlorhexidine coating the internal surface, extending into the extension set and hubs, whereas the external luminal surface is coated with chlorhexidine and silver sulfadiazine. The external surface has three times the amount of chlorhexidine and extended release of the surface-bound antiseptic agents compared with the first-generation catheters. All three prospective, randomized studies of second-generation catheters (65,66) demonstrated a significant reduction in catheter colonization, but they were underpowered to show a difference in CRBSI. Prolonged antiinfective activity provides improved efficacy in preventing infections (79). Although rare, anaphylaxis with the use of these chlorhexidine/silver sulfadiazine catheters has been observed (80).

In a multicenter randomized trial (64), CVCs impregnated on the external and internal surfaces with minocycline/rifampin were associated with lower rates of CRBSI compared with the first-generation chlorhexidine/silver sulfadiazine-impregnated catheters. The beneficial effect began after day 6 of catheterization. Silicone minocycline/rifampin-impregnated CVCs with an average dwell time of more than 60 days have been shown to be effective in reducing CRBSI. No minocycline/rifampin-resistant

Table 3. Catheter and Site Selection (11,41–67)

Recommendation	Category
Use midline catheter or PICC instead of short peripheral catheter when the duration of intravenous therapy will likely exceed 6 d	II
Use fistula or graft in patients with chronic renal failure instead of CVC for permanent access for dialysis (41)	1A
Use CVC with the minimum number of ports or lumens essential for management of patient (42–45)	IB
No recommendation can be made regarding the use of a designated lumen for parenteral nutrition	Unresolved issue
Promptly remove any intravascular catheter that is no longer essential (46–49)	IA
Weigh the risks and benefits of placing a central venous device at recommended site to reduce infectious complications against risk for mechanical complications (eg, pneumothorax, subclavian artery puncture, subclavian vein laceration, subclavian vein stenosis, hemothorax, thrombosis, air embolism, and catheter misplacement) (11,50–58)	IA
Avoid using femoral vein for central venous access in adult patients (50,57–59)	1A
Use a subclavian site, rather than jugular or femoral site, in adult patients to minimize infection risk for nontunneled CVC placement (57,58)	IB
No recommendation can be made for preferred site of insertion to minimize infection risk for tunneled CVC	Unresolved issue
Avoid subclavian site in hemodialysis patients and patients with advanced kidney disease to avoid subclavian vein stenosis (60–63)	IA
Use chlorhexidine/silver sulfadiazine or minocycline/rifampin-impregnated CVC in patients whose catheter is expected to remain in place > 5 d if, after successful implementation of a comprehensive strategy to reduce rates of CLABSI, the CLABSI rate is not decreasing; comprehensive strategy should include at least the following three components: educating persons who insert and maintain catheters, use of MSB precautions, and > 0.5% chlorhexidine preparation with alcohol for skin antisepsis during CVC insertion (64–67)	IA

CLABSI = central line–associated bloodstream infection, CVC = central venous catheter, MSB = maximum sterile barrier, PICC = peripherally inserted central catheter.

Table 4. Barrier Precautions (11,33,87,88,89)

Recommendation	Category
Use MSB precautions, including the use of cap, mask, sterile gown, sterile gloves, and sterile full-body drape, for insertion of CVCs or PICCs or guide wire exchange (33,87,88)	IB
Use new sterile gloves before handling the new catheter when guide wire exchanges are performed	1I
Wear clean or sterile gloves when changing dressing on intravascular catheters	IC
When adherence to aseptic technique cannot be ensured (ie, catheters inserted during medical emergency), replace catheter as soon as possible, ie, within 48 h (11,89)	IB

CVC = central venous catheter, MSB = maximum sterile barrier, PICC = peripherally inserted central catheter.

organisms were reported in these studies. Two trials (67) demonstrated that use of these catheters significantly reduced CRBSI compared with uncoated catheters. No comparative studies have been published using the second-generation chlorhexidine/silver sulfadiazine catheter. Several prospective clinical studies (81,82) have shown that the risk for development of resistance is low. No resistance to minocycline or rifampin related to the use of the catheter has been documented in the clinical setting.

A combination platinum/silver-impregnated catheter (ie, a silver iontophoretic catheter) is available for use in the United States. Several prospective, randomized studies (83–86) have been published comparing these catheters versus uncoated catheters. One study (85) showed a reduction in the incidence of catheter colonization and CRBSI, but the other studies (51,83,84) found no difference in catheter colonization or CRBSI between the impregnated catheter and a nonimpregnated catheter.

Barrier Precautions

Recommendations for barrier precautions are provided in **Table 4** (11,33,87–89).

MSB precautions are defined as wearing a sterile gown, sterile gloves, and cap, and using a sterile full-body drape during CVC placement. MSB precautions during insertion of CVCs were compared with the use of sterile gloves and a small drape in a randomized controlled trial (87). The MSB group had fewer episodes of catheter colonization (RR, 0.32; 95% CI, 0.10–0.96; $P = .04$) and CRBSI (relative risk, 0.16; 95% CI, 0.02–1.30; $P = .06$). In addition, in the group in which MSB precautions were used, infections occurred much later and contained Gram-negative, rather than Gram-positive, organisms. A study of pulmonary artery catheters (11) also secondarily demonstrated that use of MSB precautions lowered risk of infection. Another study (33) evaluated an educational program directed at improving infection control practices, especially MSB precautions. In this study (33), MSB precautions use increased and the incidence of CRBSI decreased. A small trial (88) demonstrated a reduced risk of skin colonization at the insertion site when MSB precautions were used (odds ratio, 3.40; 95% CI, 1.32–3.67).

Table 5. Skin Preparation (90,91)

Recommendation	Category
Prepare clean skin with > 0.5% chlorhexidine preparation with alcohol before CVC and peripheral arterial catheter insertion and during dressing changes; if there is a contraindication to chlorhexidine, tincture of iodine, an iodophor, or 70% alcohol can be used as alternatives (90,91)	IA
No comparison has been made between using chlorhexidine preparations with alcohol and povidone-iodine in alcohol to prepare clean skin	Unresolved issue
Antiseptics should be allowed to dry according to manufacturer's recommendation before placing catheter (90,91)	IB

CVC = central venous catheter.

Table 6. Dressings and Catheter Securement (96–101,107)

Recommendation	Category
Use sterile gauze or a sterile, transparent, semipermeable dressing to cover catheter site (96)	IA
If patient is diaphoretic or site is bleeding or oozing, use gauze dressing until this is resolved (96)	II
Do not use topical antibiotic ointment or creams on insertion sites, except for dialysis catheters, because of their potential to promote fungal infections and antimicrobial resistance (97,98)	IB
Do not submerge catheter or catheter site in water; showering should be permitted if precautions can be taken to reduce the likelihood of introducing organisms into the catheter (eg, if catheter and connecting device are protected with impermeable cover during shower) (99)	IB
Replace dressings used on short-term CVC sites every 2 d for gauze dressings	II
Replace dressings used on short-term CVC sites at least every 7 d for transparent dressings, except in pediatric patients in whom risk for dislodging catheter may outweigh benefit of changing dressing (100)	IB
Replace transparent dressings used on tunneled or implanted CVC sites no more often than once per week (unless dressing is soiled or loose) until the insertion site has healed	II
No recommendation can be made regarding necessity for any dressing on well-healed exit sites of long-term cuffed and tunneled CVCs	Unresolved issue
Use chlorhexidine-impregnated sponge dressing for temporary short-term catheters in patients older than 2 mo of age if CLABSI rate is not decreasing despite adherence to basic prevention measures, including education and training, appropriate use of chlorhexidine for skin antiseptics, and MSB (100,101)	1B
No recommendation made for other types of chlorhexidine dressings	Unresolved issue
Use sutureless securement device to reduce risk of infection for intravascular catheters (107)	II

CLABSI = central line–associated bloodstream infection, CVC = central venous catheter, MSB = maximum sterile barrier.

Skin Preparation

Recommendations for skin preparation are provided in **Table 5** (90,91).

Two well designed studies evaluating the chlorhexidine-containing cutaneous antiseptic regimen in comparison with povidone-iodine or alcohol for the care of an intravascular catheter insertion site (90,91) have shown lower rates of catheter colonization or CRBSI associated with the chlorhexidine preparation. (A comparison of chlorhexidine gluconate alcohol vs povidone-iodine alcohol has not been done.) When 0.5% tincture of chlorhexidine was compared with 10% povidone-iodine, no differences were seen in CVC colonization or in CRBSI (92). In a three-armed study (2% aqueous chlorhexidine gluconate vs 10% povidone-iodine vs 70% alcohol) (90), 2% aqueous chlorhexidine gluconate tended to decrease CRBSI compared with 10% povidone-iodine or 70% alcohol. A meta-analysis of 4,143 catheters (93) suggested that chlorhexidine preparation reduced the risk of catheter-related infection by 49% (95% CI, 0.28–0.88) relative to povidone-iodine. An economic decision analysis based on available evidence (94) suggested that the use of chlorhexidine, rather than povidone-iodine, for CVC care would result in a 1.6% decrease in the incidence of CRBSI, a 0.23% decrease in the incidence of death, and a

savings of \$113 per catheter used. Although chlorhexidine has become a standard antiseptic agent for skin preparation for the insertion of CVCs and peripheral venous catheters, 5% povidone-iodine solution in 70% ethanol was associated with a substantial reduction of CVC-related colonization and infection compared with 10% aqueous povidone-iodine (95).

Dressings

Recommendations for dressings are provided in **Table 6** (96–101).

A metaanalysis (102) assessed studies that compared the risk for CRBSIs with the use of transparent dressings versus gauze dressings. The risk for CRBSIs did not differ between the groups. The choice of dressing can be a matter of preference. If blood is oozing from the catheter insertion site, a gauze dressing is preferred. Another systematic review of randomized controlled trials (103) comparing gauze and tape versus transparent dressings found no significant differences between dressing types in CRBSIs, catheter tip colonization, or skin colonization.

Chlorhexidine-impregnated dressings have been used to reduce the risk of CRBSI. In the largest multicenter randomized controlled trial published to date comparing chlorhexidine-impregnated sponge dressings

Table 7. Dialysis Catheter Management (41,108–113)

Recommendation	Category
Use povidone-iodine antiseptic ointment or bacitracin/gramicidin/polymyxin B ointment at the hemodialysis catheter exit site after catheter insertion and at the end of each dialysis session only if this ointment does not interact with the material of the hemodialysis catheter per manufacturer's recommendation (41,108,109)	IB
Use prophylactic antimicrobial lock solution in patients with long-term catheters who have a history of multiple CRBSIs despite optimal maximal adherence to aseptic technique (110–113)	II

CRBSI = catheter-related bloodstream infection.

versus standard dressings in ICU patients (100), rates of CRBSIs were reduced even when background rates of infection were low. In this study (100), 1,636 patients (3,778 catheters, 28,931 catheter-days) were evaluated. The chlorhexidine-impregnated sponge dressings decreased the rate of CRBSIs (0.40 per 1,000 catheter-days vs 1.3 per 1,000 catheter-days; hazard ratio, 0.24; 95% CI, 0.09–0.65) (100). Note that there were nearly no tunneled catheters (six of 2,051 venous catheters; 0.3%) in this study (100). A randomized controlled study of polyurethane or a chlorhexidine-impregnated sponge dressing in 140 children showed no statistical difference in BSIs; however, the chlorhexidine group had lower rates of CVC colonization (104). In 601 patients with cancer receiving chemotherapy, the incidence of CRBSI was reduced in patients receiving chlorhexidine-impregnated sponge dressing compared with standard dressings ($P = .016$; relative risk, 0.54; CI, 0.31–0.94) (105). A metaanalysis that included eight randomized controlled trials demonstrated that chlorhexidine-impregnated sponge dressings are associated with a reduction of vascular and epidural catheter exit-site colonization but no significant reduction in CRBSI (2.2% vs 3.8%; odds ratio, 0.58; 95% CI, 0.29–1.14; $P = .11$) (106).

Although data regarding the use of a chlorhexidine-impregnated sponge dressing in children are limited, one randomized controlled study involving 705 neonates (101) reported a substantial decrease in colonized catheters in infants in the chlorhexidine-impregnated sponge dressing group compared with the group that received standard dressings (15% vs 24%; relative risk, 0.6; 95% CI 0.5–0.9), but no difference in the rates of CRBSI or BSI without a source. In this study (101), chlorhexidine-impregnated sponge dressings were associated with localized contact dermatitis in infants of very low birth weight.

Catheter Securement

A recommendation regarding catheter securement is provided in **Table 6** (107).

Catheter stabilization is recognized as an intervention to decrease the risk of phlebitis, catheter migration, and dislodgment, and may be advantageous in preventing CRBSIs. Pathogenesis of CRBSI occurs via migration of skin flora through the percutaneous entry site. For PICCs, sutureless securement devices avoid disruption around the catheter entry site and may decrease the degree of bacterial colonization (107). Use of a sutureless securement device also mitigates the risk of sharps injury to the health care provider from inadvertent needlestick injury. Note, however, that the need to prevent inadvertent catheter dislodgment may outweigh any advantages of sutureless securement.

Dialysis Catheter Management

Recommendations for dialysis catheter management are provided in **Table 7** (41,108–113).

A variety of topical antibiotic or antiseptic ointments have been used in attempts to lower the antimicrobial burden at the catheter insertion site and thereby prevent infection. More recent studies have examined this approach in patients at high risk, particularly those undergoing hemodialysis (109). Three randomized controlled trials have evaluated the use of 10% povidone-iodine (109). A significant decrease in colonization, exit-

site infection, or BSI was observed. The beneficial effect was most prominent in subjects with nasal colonization by *S. aureus* (109).

In the only study demonstrating a significant effect on mortality (114), the application of bacitracin/gramicidin/polymyxin B ointment at the catheter insertion site was compared with placebo in 169 patients receiving hemodialysis. There is evidence from this study that bacitracin/gramicidin/polymyxin B ointment can improve outcome, but no similar data exist for use in other patient populations (114). Gramicidin-containing ointment is not currently available in the United States.

To prevent CRBSI, a wide variety of antibiotic and antiseptic solutions have been used to flush or lock catheter lumens (110–113). Catheter lock is a technique by which an antimicrobial solution is used to fill a catheter lumen and then allowed to dwell for a period of time while the catheter is idle. At least 10 studies regarding catheter flush or lock solutions have been performed in hemodialysis patients. Three metaanalyses have all demonstrated that catheter lock solutions reduce risk of CRBSI in patients receiving hemodialysis (115–117). In the largest of these studies, 291 subjects were enrolled in a prospective randomized comparison of 30% trisodium citrate versus heparin (118). (Trisodium citrate is not approved for this use in the United States.) The rate of CRBSI was significantly lower in the group whose catheters were locked with trisodium citrate (4.1 vs 1.1 BSI per 1,000 CVC-days; $P < .001$), and no significant difference in thrombosis or occlusion of the catheter was noted. However, if infused rapidly, concentrated citrate can result in serious hypocalcaemia, cardiac dysrhythmia, and death. The second largest study in hemodialysis recipients examined the effect of a catheter lock solution containing cefazolin, gentamicin, and heparin compared with control patients receiving only heparin (119). In 120 subjects, the rate of CRBSI was significantly lower in those receiving the antibiotic lock solution (0.44 vs 3.12 BSIs per 1,000 CVC-days; $P = .03$). Other trials in patients receiving hemodialysis have studied minocycline, gentamicin, ethylenediaminetetraacetic acid, heparin, taurolidine, vancomycin, and cefotaxime. (Taurolidine is not approved for this use in the United States.)

Although most studies indicate a beneficial effect of the antimicrobial flush or lock solution in terms of prevention of catheter-related infection, this must be balanced by the potential for side effects, toxicity, allergic reactions, or emergence of resistance associated with the antimicrobial agent. The wide variety of compounds used, the heterogeneity of the patient populations studied, and limitations in the size or design of studies preclude a general recommendation for use. In addition, there are no Food and Drug Administration–approved formulations approved for marketing, and most formulations have been prepared in hospital pharmacies.

Replacement of Midline Catheters

A recommendation regarding the replacement of midline catheters is provided in **Table 8** (11,120–123).

Midline catheters are associated with lower rates of phlebitis than short peripheral catheters and with lower rates of infection than CVCs (120–122). In one prospective study of 140 midline catheters (122), their use was associated with a BSI rate of 0.8 per 1,000 catheter-days. No specific risk factors, including duration of catheterization, were associated

Table 8. Replacement of Midline Catheters and CVCs (11,122–125)

Recommendation*	Category
Replace midline catheters only when there is a specific indication (112)	II
Do not routinely replace CVCs, PICCs, hemodialysis catheters, or pulmonary artery catheters to prevent catheter-related infections (123,124)	IB
Do not remove CVCs or PICCs on the basis of fever alone; use clinical judgment regarding appropriateness of removing catheter if infection is evidenced elsewhere or noninfectious cause of fever is suspected	II
Do not use guide wire exchanges routinely for nontunneled catheters to prevent infection (125)	IB
Do not use guide wire exchanges to replace a nontunneled catheter suspected of infection (11)	IB
Use guide wire exchange to replace malfunctioning nontunneled catheter if no evidence of infection is present	IB
Use new sterile gloves before handling new catheter when guide wire exchanges are performed	II

CVC = central venous catheter, PICC = peripherally inserted central catheter.

with infection. Midline catheters were in place for a median of 7 days, but for as long as 49 days. Although the findings of this study (122) suggested that midline catheters could be changed only when there is a specific indication, no prospective, randomized studies have assessed the benefit of routine replacement as a strategy to prevent CRBSI associated with midline catheters.

Replacement of CVCs

Recommendations for replacement of CVCs are provided in **Table 8** (11,122–125).

Catheter replacement (ie, removal and placement at a new site) at scheduled time intervals as a method to reduce CRBSI has not lowered rates. Two trials (123,124) have assessed a strategy of changing the catheter every 7 days compared with a strategy of changing catheters as needed. One of these studies (123) involved 112 surgical ICU patients who required CVCs, pulmonary artery catheters, or peripheral arterial catheters, whereas the other study (124) involved only subclavian hemodialysis catheters. In both studies, no difference in CRBSI was observed in patients undergoing scheduled catheter replacement every 7 days compared with patients whose catheters were replaced as needed.

Scheduled guide wire exchange of CVCs is another proposed strategy for the prevention of CRBSI. The results of a metaanalysis of 12 randomized, controlled trials assessing CVC management (125) failed to demonstrate any reduction of CRBSI rates through routine replacement of CVCs by guide wire exchange compared with catheter replacement on an as-needed basis. Therefore, routine replacement of CVCs is not necessary for catheters that are functioning and have no evidence of causing local or systemic complications.

Exchange of temporary catheters over a guide wire in the presence of bacteremia is not an acceptable replacement strategy because the source of infection is usually colonization of the skin tract from the insertion site to the vein (11,126). However, in selected patients with tunneled hemodialysis catheters and bacteremia, catheter exchange over a guide wire, in combination with antibiotic therapy, is an alternative as a salvage strategy in patients with limited venous access (127–129).

The use of catheters for hemodialysis is the most common factor contributing to bacteremia in patients receiving dialysis (130). The relative risk for bacteremia in patients with dialysis catheters is seven times the risk for patients with arteriovenous fistulas. Arteriovenous fistulas and grafts are preferred versus hemodialysis catheters in patients with chronic renal failure as a result of their lower associated risk of infection. If temporary access is needed for dialysis, a tunneled cuffed catheter is preferable to a noncuffed catheter, even in the ICU setting, if the catheter is expected to stay in place for more than 3 weeks (41).

SUMMARY

The 2011 Guidelines for the Prevention of Intravascular Catheter-related Infections (8) contain current recommendations for the selection, place-

ment, maintenance, and replacement of catheters used for venous access. This material is directly relevant to the day-to-day practice of interventional radiology. Highlights of the Guidelines are presented here. The Guidelines contain additional recommendations related to pediatric use, arterial catheters, and other topics, and extensive background information and references (8). Physicians who perform these procedures may wish to review the entire document.

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The clinical practice guidelines of the Society of Interventional Radiology attempt to define practice principles that generally should assist in producing high quality medical care. These guidelines are voluntary and are not rules. A physician may deviate from these guidelines, as necessitated by the individual patient and available resources. These practice guidelines should not be deemed inclusive of all proper methods of care or exclusive of other methods of care that are reasonably directed towards the same result. Other sources of information may be used in conjunction with these principles to produce a process leading to high quality medical care. The ultimate judgment regarding the conduct of any specific procedure or course of management must be made by the physician, who should consider all circumstances relevant to the individual clinical situation. Adherence to the SIR Quality Improvement Program will not assure a successful outcome in every situation. It is prudent to document the rationale for any deviation from the suggested practice guidelines in the department policies and procedure manual or in the patient's medical record.