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

Donald L. Miller, MD, and Naomi P. O'Grady, MD

THE revised version of the Centers for Disease Control Guidelines for the Prevention of Intravascular Catheter-related Infections was published on August 9, 2002, in the *Morbidity and Mortality Weekly Report* Reports and Recommendations series (1). It replaces the previous guideline published in 1996. The goal of the new guidelines is to provide evidence-based recommendations for preventing catheter-related infections. The new document was prepared by a working group 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, Society of Interventional Radiology, American Academy of Pediatrics, and the Healthcare Infection Control Practices Advisory Committee of the Centers for Disease Control.

Major areas of emphasis in the new guidelines include (i) education and training of health-care providers who insert and maintain catheters, (ii) use of maximal sterile barrier precautions during central venous catheter (CVC) insertion, (iii) use of a 2% chlorhexidine preparation for skin antisepsis, (iv) avoidance of routine replacement of CVCs as a strategy to prevent infection, and (v) use of antiseptic- or antibiotic-impregnated short-term CVCs if the rate of infection is high despite adherence to other strategies (ie, education and training, maximum sterile barrier precautions, and 2% chlorhexidine for skin antisepsis). The full guideline, available without charge at *http://www.cdc.gov/mmwr/PDF/RR/RR5110.pdf*, is lengthy and includes numerous other recommendations (1). 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. Selected recommendations are presented verbatim here, along with selected supporting data, background information, and references.

EPIDEMIOLOGY AND MICROBIOLOGY

The incidence of catheter-related bloodstream infections (CR-BSIs) varies considerably by type of catheter, frequency of catheter manipulation, and patient-related factors (eg, underlying disease and acuity of illness). Most serious catheter-related infections are associated with CVCs, especially those that are placed in patients in intensive care units (ICUs). In the United States, the estimated attributable cost per infection in the ICU is $35,000–$56,000 (2,3). For entire hospitals, as opposed to ICUs only, 250,000 cases of CVC-associated BSIs have been estimated to occur annually in the United States (4). In this case, attributable mortality is an estimated 12%–25% for each infection, and the marginal cost to the health-care system is $25,000 per episode (4).

Pooled data from 1992 through 1999 indicate that coagulase-negative staphylococci are now the most frequently isolated causes of hospital-acquired BSIs (37%), followed by enterococci (13.5%) (1). The percentage of enterococcal ICU isolates resistant to vancomycin increased from 0.5% in 1989 to 25.9% in 1999 (5). *Candida* species caused 8% of hospital-acquired BSIs from 1992 to 1999.

PATHOGENESIS

Migration of skin organisms at the insertion site into the cutaneous catheter tract, with colonization of the catheter tip, is the most common route of infection for peripherally inserted short-term catheters (6,7). Contamination of the catheter hub contributes substantially to intraluminal colonization of long-term catheters (8–10). Occasionally, catheters may become hematogenously seeded from another focus of infection. Rarely, infusate contamination leads to CR-BSI (11).

Recommendations

- Use a CVC with the minimum number of ports or lumens essential for the management of the patient.
- Use totally implantable access devices for patients who require long-term, intermittent vascular access. For patients requiring frequent or continuous access, a PICC or tunneled CVC is preferable.

SITE OF CATHETER INSERTION

The site at which a catheter is placed influences the subsequent risk of catheter-related infection and phlebitis. The density of skin flora at the catheter insertion site is a major risk factor for CR-BSI. No randomized trial has satisfactorily compared infection rates for catheters placed in jugular, subclavian, and femoral sites. Catheters inserted into an internal jugular vein have been associated with higher risk of infection than those inserted into a subclavian or femoral vein (7,12,13). Therefore, in adult patients, a subclavian site is preferred for infection-control purposes, even though other factors (eg, the potential for mechanical complications, risk of subclavian vein stenosis, and catheter operator skill) must be considered when deciding where to place the catheter.

Recommendations

- Weigh the risks and benefits of placing a device at a recommended site to reduce infectious complications against the risk for mechanical complications (eg,

pneumothorax, subclavian artery puncture, subclavian vein laceration, subclavian vein stenosis, hemothorax, thrombosis, air embolism, and catheter misplacement).
- Use a subclavian site (rather than a jugular or femoral site) in adult patients to minimize infection risk for nontunneled CVC placement.
- No recommendation can be made for a preferred site of insertion to minimize infection risk for a tunneled CVC.
- Place catheters used for hemodialysis and pheresis in a jugular or femoral vein rather than a subclavian vein to avoid venous stenosis if catheter access is needed.

ASEPTIC TECHNIQUE

Compared with peripheral venous catheters, CVCs carry a substantially greater risk of infection. Maximum sterile barrier precautions (eg, cap, mask, sterile gown, sterile gloves, and large sterile drape) during the insertion of CVCs significantly reduce the incidence of CR-BSI compared with standard precautions (eg, sterile gloves and small drapes) (7,14). Although the efficacy of such precautions for insertion of PICCs has not been studied, the use of maximum barrier precautions is likely also applicable to PICCs.

In the United States, povidone iodine has been the most widely used antiseptic for cleansing arterial catheter and CVC insertion sites (15). However, in one study, preparation of central venous and arterial sites with 2% aqueous chlorhexidine gluconate reduced BSI rates compared with site preparation with 10% povidone iodine or 70% alcohol (16). The U.S. Food and Drug Administration has approved a 2% tincture of chlorhexidine preparation for skin antisepsis. Other preparations of chlorhexidine may not be as effective.

Recommendations

- Use aseptic technique including the use of a cap, mask, sterile gown, sterile gloves, and a large sterile sheet for the insertion of

CVCs (including PICCs) or guide-wire exchange.
- Although a 2% chlorhexidine-based preparation is preferred, tincture of iodine, an iodophor, or 70% alcohol may be used. Allow the antiseptic to remain on the insertion site and to air dry before catheter insertion. Allow povidone iodine to remain on the skin for at least 2 minutes, or longer if it is not yet dry before insertion.

ANTIMICROBIAL- OR ANTISEPTIC-IMPREGNATED CATHETERS AND CUFFS

Certain catheters and cuffs that are coated or impregnated with antimicrobial or antiseptic agents can decrease the risk of CR-BSI and potentially decrease hospital costs associated with treating CR-BSIs despite the additional acquisition cost of an antimicrobial- or antiseptic-impregnated catheter. Two meta-analyses demonstrated that catheters coated with chlorhexidine/silver sulfadiazine on the external luminal surface reduced the risk of CR-BSI compared with standard noncoated catheters (17,18). In a multicenter randomized trial, CVCs impregnated on the external and internal surfaces with minocycline/rifampin were associated with lower rates of CR-BSI when compared with the first-generation chlorhexidine/silver sulfadiazine–impregnated catheters (19). All of the studies involving antimicrobial- or antiseptic-impregnated catheters have been conducted with use of triple-lumen, noncuffed catheters in adult patients whose catheters remained in place for less than 30 days.

Ionic silver has been used in subcutaneous collagen cuffs attached to CVCs. In studies of catheters left in place longer than 20 days, the cuff failed to reduce the incidence of CR-BSI (20,21). Two other studies of short-term catheters could not demonstrate efficacy because of the minimal number of CR-BSIs observed (22,23).

Recommendation

- Use an antimicrobial- or antiseptic-impregnated CVC in adults whose catheter is expected to remain in place >5 days if, after implementing a comprehensive

strategy to reduce rates of CR-BSI, the CR-BSI rate remains above the goal set by the individual institution based on benchmark rates and local factors.

CATHETER FIXATION AND DRESSING

Sutureless fixation devices may be preferable to sutures in preventing CR-BSIs. One study, which involved only a limited number of patients and was underpowered, compared a sutureless device to suture for securing PICCS; in this study, CR-BSI was reduced in the group of patients that received the sutureless device (24).

Povidone iodine ointment applied at the insertion site of hemodialysis catheters has been studied as a prophylactic intervention to reduce the incidence of catheter-related infections. One randomized study of 129 hemodialysis catheters demonstrated a reduction in the incidence of exit-site infections, catheter-tip colonization, and BSIs with the routine use of povidone iodine ointment at the catheter insertion site compared to use of no ointment at the insertion site (25).

Several studies have evaluated the effectiveness of mupirocin ointment applied at the insertion sites of CVCs as a means to prevent CR-BSI. Although mupirocin ointment reduced the risk of CR-BSI, it has also been associated with mupirocin resistance and may adversely affect the integrity of polyurethane catheters.

Recommendations

- Do not use topical antibiotic ointment or creams on insertion sites (except when using dialysis catheters) because of their potential to promote fungal infections and antimicrobial resistance.
- Tunneled CVC sites that are well healed may not require dressings.

CENTRAL VENOUS CATHETER REPLACEMENT

Catheter replacement at scheduled time intervals as a method to reduce CR-BSI has not lowered rates. This is true regardless of whether catheters were placed at new sites or replaced over a guide wire. Routine replacement of CVCs is not necessary for catheters that are functioning and are not shown to cause local or systemic complications.

Replacement 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 (7,26). However, in selected patients with tunneled hemodialysis catheters and bacteremia, catheter exchange over a guide wire, in combination with antibiotic therapy, may be an alternative salvage strategy in patients with limited venous access (27–30).

Recommendations

- Do not routinely replace CVCs, PICCs, hemodialysis catheters, or pulmonary artery catheters to prevent catheter-related infections.
- Do not remove CVCs or PICCs on the basis of fever alone. Use clinical judgment regarding the appropriateness of removing the catheter if infection is evidenced elsewhere or if a noninfectious cause of fever is suspected.
- Do not use guide-wire techniques to replace catheters in patients suspected of having catheter-related infection.

HEMODIALYSIS CATHETERS

The use of catheters for hemodialysis is the most common factor contributing to bacteremia in patients undergoing dialysis. The relative risk for bacteremia in patients with dialysis catheters is seven times the risk in patients with primary arteriovenous fistulas (31). Hemodialysis catheters should be avoided in favor of arteriovenous fistulas and grafts. If temporary access is needed for dialysis, a cuffed catheter is preferable to a noncuffed catheter if the catheter is expected to stay in place for longer than 3 weeks (4,32).

Recommendation

- Use a cuffed CVC for dialysis if the period of temporary access is anticipated to be prolonged (eg, >3 weeks).

CENTRAL VENOUS CATHETERS IN CHILDREN

Because of the limited vascular sites in children, attention should be given to the frequency with which catheters are replaced in these patients. In a study in which survival analysis techniques were used to examine the relationship between the duration of central venous catheterization and complications in pediatric patients in the ICU, all patients studied ($n = 397$) remained without infection for a median of 23.7 days (33). In addition, no relationship was found between duration of catheterization and the daily probability of infection ($r = 0.21$, $P > .1$), suggesting that routine replacement of CVCs likely does not reduce the incidence of catheter-related infection (33).

SUMMARY

The new *Guidelines for the Prevention of Intravascular Catheter-related Infections* contain comprehensive recommendations for the selection, placement, 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, extensive background information, and references. Review of the entire document is recommended for all physicians who perform venous access procedures.

References

1. Centers for Disease Control. Guidelines for the prevention of intravascular catheter-related infections. MMWR Morb Mortal Wkly Rep 2002; 51 (No. RR 10):1–36.
2. Rello J, Ochagavia A, Sabanes E, et al. Evaluation of outcome of intravenous catheter-related infections in critically ill patients. Am J Respir Crit Care Med 2000; 162:1027–1030.
3. Dimick JB, Pelz RK, Consunji R, Swoboda SM, Hendrix CW, Lipsett PA. Increased resource use associated with catheter-related bloodstream infection in the surgical intensive care unit. Arch Surg 2001; 136:229–234.
4. Kluger DM, Maki DG. The relative risk of intravascular device related bloodstream infections in adults [abstract]. In: Abstracts of the 39th Interscience Conference on Antimicrobial

Agents and Chemotherapy; San Francisco, Calif. American Society for Microbiology, 1999:514.

5. Centers for Disease Control. National Nosocomial Infections Surveillance (NNIS) System report, data summary from January 1990–May 1999, issued June 1999. Am J Infect Control 1999; 27:520–532.

6. Maki DG, Weise CE, Sarafin HW. A semiquantitative culture method for identifying intravenous-catheter-related infection. N Engl J Med 1977; 296:1305–1309.

7. Mermel LA, McCormick RD, Springman SR, Maki DG. The pathogenesis and epidemiology of catheter-related infection with pulmonary artery Swan-Ganz catheters: a prospective study utilizing molecular subtyping. Am J Med 1991; 91(3B):197S–205S.

8. Sitges-Serra A, Linares J, Perez JL, Jaurrieta E, Lorente L. A randomized trial on the effect of tubing changes on hub contamination and catheter sepsis during parenteral nutrition. JPEN J Parenter Enteral Nutr 1985; 9:322–325.

9. Linares J, Sitges-Serra A, Garau J, Perez JL, Martin R. Pathogenesis of catheter sepsis: a prospective study with quantitative and semiquantitative cultures of catheter hub and segments. J Clin Microbiol 1985; 21:357–360.

10. Raad I, Costerton W, Sabharwal U, Sacilowski M, Anaissie E, Bodey GP. Ultrastructural analysis of indwelling vascular catheters: a quantitative relationship between luminal colonization and duration of placement. J Infect Dis 1993; 168:400–407.

11. Maki DG. Infections associated with intravascular lines. In: Remington JS, ed. Current Clinical Topics in Infectious Diseases. New York: McGraw-Hill, 1982; 309–363.

12. Heard SO, Wagle M, Vijayakumar E, et al. Influence of triple-lumen central venous catheters coated with chlorhexidine and silver sulfadiazine on the incidence of catheter-related bacteremia. Arch Intern Med 1998; 158:81–87.

13. Richet H, Hubert B, Nitemberg G, et al. Prospective multicenter study of vascular-catheter-related complications and risk factors for positive central-catheter cultures in intensive care unit patients. J Clin Microbiol 1990; 28:2520–2525.

14. Raad II, Hohn DC, Gilbreath BJ, et al. Prevention of central venous catheter-related infections by using maximal sterile barrier precautions during insertion. Infect Control Hosp Epidemiol 1994; 15:231–238.

15. Clemence MA, Walker D, Farr BM. Central venous catheter practices: results of a survey. Am J Infect Control 1995; 23:5–12.

16. Maki DG, Ringer M, Alvarado CJ. Prospective randomised trial of povidone-iodine, alcohol, and chlorhexidine for prevention of infection associated with central venous and arterial catheters. Lancet 1991; 338:339–343.

17. Mermel LA. Prevention of intravascular catheter-related infections. Ann Intern Med 2000; 132:391–402.

18. Veenstra DL, Saint S, Saha S, Lumley T, Sullivan SD. Efficacy of antiseptic-impregnated central venous catheters in preventing catheter-related bloodstream infection: a meta-analysis. JAMA 1999; 281:261–267.

19. Darouiche RO, Raad II, Heard SO, et al. A comparison of two antimicrobial-impregnated central venous catheters. Catheter Study Group. N Engl J Med 1999; 340:1–8.

20. Dahlberg PJ, Agger WA, Singer JR, et al. Subclavian hemodialysis catheter infections: a prospective, randomized trial of an attachable silver-impregnated cuff for prevention of catheter-related infections. Infect Control Hosp Epidemiol 1995; 16:506–511.

21. Groeger JS, Lucas AB, Coit D, et al. A prospective, randomized evaluation of the effect of silver impregnated subcutaneous cuffs for preventing tunneled chronic venous access catheter infections in cancer patients. Ann Surg 1993; 218:206–210.

22. Maki DG, Cobb L, Garman JK, Shapiro JM, Ringer M, Helgerson RB. An attachable silver-impregnated cuff for prevention of infection with central venous catheters: a prospective randomized multicenter trial. Am J Med 1988; 85:307–314.

23. Bonawitz SC, Hammell EJ, Kirkpatrick JR. Prevention of central venous catheter sepsis: a prospective randomized trial. Am Surg 1991; 57:618–623.

24. Yamamoto AJ, Solomon JA, Soulen MC, et al. Sutureless securement device reduces complications of peripherally inserted central venous catheters. J Vasc Interv Radiol 2002; 13:77–81.

25. Levin A, Mason AJ, Jindal KK, Fong IW, Goldstein MB. Prevention of hemodialysis subclavian vein catheter infections by topical povidone-iodine. Kidney Int 1991; 40:934–938.

26. Cobb DK, High KP, Sawyer RG, et al. A controlled trial of scheduled replacement of central venous and pulmonary-artery catheters. N Engl J Med 1992; 327:1062–1068.

27. Robinson D, Suhocki P, Schwab SJ. Treatment of infected tunneled venous access hemodialysis catheters with guidewire exchange. Kidney Int 1998; 53:1792–1794.

28. Beathard GA. Management of bacteremia associated with tunneled-cuffed hemodialysis catheters. J Am Soc Nephrol 1999; 10:1045–1049.

29. Saad TF. Bacteremia associated with tunneled, cuffed hemodialysis catheters. Am J Kidney Dis 1999; 34:1114–1124.

30. Duszak R Jr, Haskal ZJ, Thomas-Hawkins C, et al. Replacement of failing tunneled hemodialysis catheters through pre-existing subcutaneous tunnels: a comparison of catheter function and infection rates for de novo placements and over-the-wire exchanges. J Vasc Interv Radiol 1998; 9:321–327.

31. Hoen B, Paul-Dauphin A, Hestin D, Kessler M. EPIBACDIAL: a multicenter prospective study of risk factors for bacteremia in chronic hemodialysis patients. J Am Soc Nephrol 1998; 9:869–876.

32. National Kidney Foundation. NKF-K/DOQI clinical practice guidelines for vascular access: update 2000. Am J Kidney Dis 2001; 37 (Suppl 1):S137–S181.

33. Stenzel JP, Green TP, Fuhrman BP, Carlson PE, Marchessault RP. Percutaneous central venous catheterization in a pediatric intensive care unit: a survival analysis of complications. Crit Care Med 1989; 17:984–988.