Chapter 17

Prevention of Intravascular Device-Associated Infections

Chellie DeVries

Key Points
• Carefully consider the indications for vascular access when determining the type (central, midline, peripheral, intraosseus) and location of a device. • Thorough hand sanitising or antisepsis by operator before insertion of catheter and during maintenance procedures. • Thorough antisepsis of skin at insertion site. • No-touch technique or gloved hands during insertion, maintenance, and removal of catheter. • Secure the intravascular line to prevent movement of the catheter. • Maintain a closed system. • Protect the insertion site with a sterile dressing. • Assess catheter site daily without manipulation of dressing, unless palpation suggests need for direct observation. • Remove the catheter as early as possible and immediately if any signs of infection are present. • Do not reuse catheters that are intended for single use.

Introduction

Intravenous (IV) insertions are among the most common invasive procedures performed in health care; infusions are administered either by peripheral or central routes. Central line-associated bloodstream infections (CLABSI) can be common, however they are largely preventable. CLABSIs are responsible for increased length of stay (LOS), attributable mortality, and increased health care costs, both in high-income[1] and limited -resource countries.[2-3] Infections associated with peripheral catheters may occur, however with a much lower incidence. The principles used for preventing infection are similar for both central and peripheral catheters.[4]

The incidence of CLABSI is many times underestimated in limited-resource countries, as basic infection prevention and control (IPC) programs may not be systematically implemented. CLABSI rates in the intensive care units (ICU) of limited-resources countries are 3 to 5 times higher than in high-income countries, as reported by the International Nosocomial Infection Control Consortium (INICC) in pooled studies.[5] In this sense, it should be noted that the socio-economic level of a country has an impact on healthcare-associated infection rates in the ICU settings of limited-resource countries.[6-7]

An IV catheter is a foreign body that produces a reaction in the host which may result in a layer of fibrinous material on the catheter's inner and outer surfaces. These proteins may become colonised by microorganisms within a biofilm that are then protected from host defence mechanisms and the effect of antimicrobials.[8] Both local and systemic infection may result from contamination or colonisation of intravascular devices. Cellulitis, abscess formation, septic thrombophlebitis, bacteraemia, or endocarditis may occur as complications of intravascular therapy and monitoring.

IPC measures are designed to prevent contamination of intravascular devices from microorganisms entering equipment, catheter insertion sites, and ultimately the bloodstream. See Figure 17.1. Because of the risk of blood-borne pathogen transmission to patients and staff, do *not* reuse intravascular devices; they are intended for single use only.

Healthcare personnel should be educated about insertion, care, and maintenance of intravascular devices. Their knowledge of and adherence to preventive measures should be assessed periodically.[8-11]

Because of the potential for infection, IV catheters should not be inserted unnecessarily. They should be used only for strict medical indications, e.g., severe dehydration, blood transfusion, or parenteral feeding. Whenever possible, use alternative routes for hydration or parenteral therapy. Once catheters have been inserted, the need for them should be assessed daily. Catheters not required for patient care should be removed as soon as possible.[12-13]

Strict asepsis is required for insertion of the catheter and maintenance of the insertion site. The site should be kept dry, free from contamination, secured, and dressed in a position which is as comfortable as possible for the patient.

Sources and Routes of Transmission

Sources of contamination of the device as well as the infusate are either intraluminal (contamination within the interior of the catheter) or extraluminal (contamination introduced along the exterior of the catheter or insertion site). Although less frequent, infusate can be intrinsically contaminated as well. Most of the microorganisms that cause intravascular device-related infections are from the patient's own skin flora; however, contamination of a device hub is also a source of infection.[14-15] Gram-positive bacteria (i.e., methicillin-resistant and sensitive *S. aureus*, coagulase-negative staphylococci) account for 60 to 90% of infections. Less frequently, Gram-negative bacilli (including multiresistant *Acinetobacter baumannii*) or *Candida species* may cause infection.[16-17] Pathogen susceptibilities and distribution vary widely by region and over time.

Skin microorganisms may enter the catheter insertion site along the outside of the catheter. Microorganisms from the hands of staff or the patient's skin may enter through the hub when the catheter is disconnected or through injection ports. In particular, coagulase-negative staphylococci can adhere to polymer device surfaces more effectively than other microorganisms. The bacteria grow in the biofilm created, usually on the catheter's outer surface, and may be released into the bloodstream.

Less frequently, microorganisms growing in inadequately sterilised, commercially- or locally-prepared infusions or medications have caused CLABSIs.[18] Infections originating from contaminated infusates may appear as clusters of bloodstream infections in more than one patient. Finally, colonisation of the catheter tip may occur, seeded from a distant site of infection (e.g., wound, lung, or kidney).

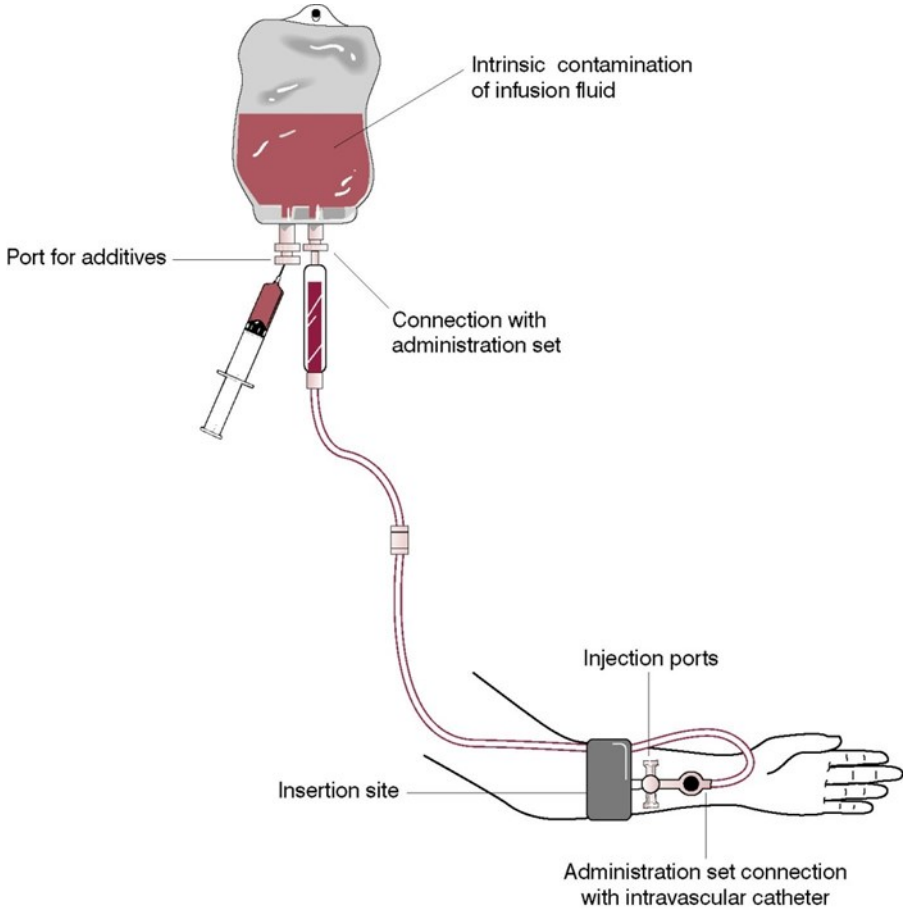

Figure 17.1. Sites of possible contamination of intravascular infusions [Reproduced with permission from Damani NN and Keyes JK. Craigavon Infection Control Manual, 2004]

Source of Infection and Prevention

Table 17.1 outlines the major sources of contamination related to intravascular catheters.

General Comments

Unless signs of infection or irritation occur, peripheral IV catheters do not require routine changes in adults or children, when aseptic technique for insertion and care of intravascular catheters is followed.[11,19] This updates a previous recommendation to change peripheral catheters in adults at least every 72-96 hours.

Do not submerge the catheter or catheter site in water. Showering should be permitted if precautions can be taken to reduce the likelihood of introducing microorganisms into the catheter. One method is protecting

the catheter and connecting device with an impermeable cover during showering.

Protocol for placement of peripheral IV catheters

- Place arm on a clean sheet or towel.
- Hand Hygiene
  - Operator uses an alcohol-based hand rub or antiseptic soap to clean hands. If these are not available, wash hands thoroughly with plain soap for at least 15 seconds.
  - Rinse hands with potable water if washing with soap
  - Dry hands thoroughly on a paper or freshly washed, unused linen towel, unless alcohol-based hand rub is used.
  - The use of gloves does not eliminate the need for hand hygiene.
- Preparation
  - If it is necessary to remove hair from the insertion site, clip the hair; avoid shaving.
  - Disinfect clean skin site with >0.5% chlorhexidine (CHG)-alcohol, 2% tincture of iodine, 10% alcoholic povidone-iodine, or 70% alcohol (isopropanol). Apply with rubbing for 30 seconds and allow complete drying before inserting the IV cannula.
  - CHG products should be used with care on premature infants or infants less than 2 months of age.[13]
  - Insert cannula into vein, preferably in an upper limb, without touching skin.
  - If re-palpation is necessary after skin prep, sterile gloves are to be worn or perform a new application of antiseptic.
- Insertion
  - Repeated attempts to insert IVs increase risk of complication, impact vessel viability for future access, and contribute to patient pain.
  - Develop plans to identify best opportunities to minimise the total number of attempts.
  - Select the site most likely to allow completion of therapy; consider the forearm preferentially.[19]
- Insertion Site
  - Apply sterile dressing (gauze or equivalent or clear semi-permeable) and secure.
  - Semi-permeable adhesive dressings are more expensive; however they allow inspection of the site without removal of the dressing, as well as necessitate less frequent dressing changes.
  - Inspect site at least daily.
  - Change transparent dressings regularly, at least once a week or more frequently if the dressing is soiled, loose, or damp.
  - Gauze dressings should be inspected daily, either at the time of dressing change or by palpation through an intact dressing, or changed every two days.
  - When changing the dressing, clean the site with CHG-alcohol, 2% tincture of iodine, 10% alcoholic povidone-iodine, or 70% alcohol (isopropanol).
  - Secure cannula to avoid movement and label with insertion date.
- Assess the need for continuing catheterisation at least every 24 hours.
- Inspect catheter daily and remove at first sign of infection or other complications.
- Cannulae and administration sets must be sterile before use. It is preferable to use single-use, disposable products.

Protocol for placement of central catheters

- Selection
  - Site selection may be an important risk factor for infection: higher infection rates have been observed for jugular and femoral rather than subclavian sites.
  - Careful consideration of single versus multiple lumen needs and tunnelled versus non-tunnelled devices and may also serve to reduce bloodstream infection risk.
  - Clear indications for central venous access can help guide these decisions.
- Preparation
  - Use maximum barrier precautions: sterile gloves, gowns, cap, and mask for operator and a large sterile drape to cover the patient.[21-22]
  - Disinfect skin site with 2% CHG-alcohol. If not available, povidone-iodine, preferably with alcohol, or 70% isopropyl alcohol may be used. Allow drying before inserting the catheter.
- Insertion Site
  - If available, apply a CHG sponge dressing. Use with caution in patients greater than 2 months old.
  - Change transparent dressings regularly, at least once a week or more frequently if the dressing is soiled, loose, or damp.
  - Gauze dressings should be changed every two days.
  - When changing the dressing, disinfect the site with CHG-alcohol, preferably, or with povidone-iodine, preferably with alcohol, or 70% isopropyl alcohol.
- Replace administration sets not used for blood, blood products, or lipids at intervals no more frequently than 72 hours.

Measures that should **not** be considered as part of a general prevention policy:

- Systemic antibiotic prophylaxis while the catheter is in situ.
- Topical use of antimicrobial ointments or creams at the insertion site.
- Routine replacement of central venous catheters.
- Routine use of antibiotic locks for central venous catheters.
- Routine use of in-line filters.

Additional considerations

Antibiotic locks

Antibiotic lock solutions may be considered in patients with CLABSI with long term devices, but without tunnel or pocket infections, to attempt to salvage the device in conjunction with systemic antibiotics. It may also be appropriate to consider in patients with history of CLABSI or high-risk complications. Routine use of antibiotic locks is discouraged due to concerns of developing resistance.[19] Patients with long term haemodialysis catheters may also be appropriate candidates to consider for using antibiotic lock solutions.[13]

Antibiotic/silver impregnated catheters

There is strong evidence to support to use of impregnated catheters in adult populations when facilities are unable to maintain low CLABSI rates despite compliance with core recommendations. Suggested populations to consider include specific units or areas experiencing higher rates of infections, patients with recurrent CLABSIs and limited venous access, and patients who may be at greater risk of more serious complications should a CLABSI develop.[13] Their use may also be considered in patients in whom dwell time is anticipated to

be greater than 5 days.[19] Use of these catheters is less likely to be beneficial in areas with already low rates of infection.

Checklists

The use of checklists, particularly for central line insertion, has been well demonstrated to help standardise care and promote improved outcomes. Ensuring that staff is empowered to interrupt the process if steps are not complied with is essential; provide follow-up to individual providers not meeting expectations.[23] The USA's Center for Disease Control and Prevention has a checklist that includes insertion and ongoing care considerations, as well as facility considerations.[21,24]

There are also peripheral IV insertion bundles which can be easily converted to a checklist. They are used in the United Kingdom as part of their Saving Lives bundles.[25] Australia has a very comprehensive Procedure Compliance Checklist: Peripheral Intravenous Catheter tool which serves as a means to evaluate compliance with best practices.[26]

Parenteral fluid issues

Ensuring sterility of parenteral fluids is crucial to minimise risk of infection; contaminated infusates are a direct route into the patient's bloodstream. Strict compounding guidance is crucial and requires continuous monitoring.

Similarly, inappropriately maintained fluids (not replaced at specified intervals) may also needlessly expose patients to risk. Clearly communicating hang times for items such as blood, lipid-containing emulsions, and certain medications and auditing for compliance is also necessary to reduce risk of infections.[19]

Chlorhexidine bathing

CHG bathing has been used with success both for prevention of surgical site infections as well as CLABSIs and, in conjunction with broader efforts, methicillin-resistant *S. aureus* reduction.[8,13,27] It is considered a standard to use in performing daily bathing for all patients (other than neonates), without limitations to specific populations. Most of the research has been focused specifically on critical care patients and long term acute care.

If using liquid formulations rather than CHG cloths, policies must be carefully developed to ensure appropriate concentrations and contact time to achieve desired results.

Changing Central Catheters

- No need to routinely change to reduce risk of infection.
- Clinical need for continued use should be assessed daily.
- If necessary to change, preferably change to a new site rather than over a guidewire.[11]

Accessing IV catheters

Access ports should be disinfected when using a line for infusion or aspiration. Unused stopcocks or access ports should be capped when not in use.

Surveillance

Systemically monitoring and measuring incidence of infections and associated risk factors is crucial for determining opportunities for improvement.

References

1. Stone PW, Braccia D, Larson E. Systematic review of economic analyses of health care-associated infec-

tions. *Am J Infect Control* 2005; 33:501-9.

2. Rosenthal VD, Guzman S, Migone O, Crnich CJ. The attributable cost, length of hospital stay, and mortality of central line-associated bloodstream infection in intensive care departments in Argentina: A prospective, matched analysis. *Am J Infect Control* 2003; 31:475-80.
3. Higuera F, Rangel-Frausto MS, Rosenthal VD, et al. Attributable cost and length of stay for patients with central venous catheter-associated bloodstream infection in Mexico City intensive care units: a prospective, matched analysis. *Infect Control Hosp Epidemiol* 2007;28:31-5.
4. DeVries M, Valentine MJ. Bloodstream Infections from Peripheral Lines: An Underrated Risk. http://www.americannursetoday.com/piv/ [Accessed 29 January, 2016]
5. Rosenthal VD, Maki DG, Mehta Y, et al. International Nosocomial Infection Control Consortium (INICC) report, data summary of 43 countries for 2007-2012. Device-associated module. *Am J Infect Control* 2014; 42:942-56.
6. Rosenthal VD, Jarvis WR, Jamulitrat S, et al. Socioeconomic impact on device-associated infections in pediatric intensive care units of 16 limited-resource countries: International Nosocomial Infection Control Consortium findings. *Ped Crit Care Med* 2012; 13(4):399-406.
7. Rosenthal VD, Lynch P, Jarvis WR, et al. Socioeconomic impact on device-associated infections in limited-resource neonatal intensive care units: findings of the INICC. *Infection* 2011;39:439-50.
8. Guidelines for the Prevention of Intravascular Catheter-Related Infections, 2011. *Clin Infect Dis* 2011; 52 (9):e162-93. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3106269/ [Accessed 10 February 2016]
9. Beekmann SE, Henderson DK. Infection caused by percutaneous intravascular devices. In: G.L.Mandell, J.E.Bennett, R. Dolin, *Mandell, Douglas, and Bennett's principles and practice of infectious diseases*, 7th edn, Philadelphia, PA: Churchill, Livingstone, Elsevier, 2010, vol. II, pp. 3697-715.
10. Sherertz RJ, Ely EW, Westbrook EM, et al. Education of physicians-in-training can decrease the risk for vascular catheter infection. *Ann Intern Med* 2000; 132: 641-8.
11. Loveday HP, Wilson JA, Pratt RJ, et al. epic3: National Evidence-Based Guidelines for Preventing Healthcare-Associated Infections in NHS Hospitals in England. *J Hosp Infect* 2014; 86S1:S1–S70.
12. Warren DK, Zack JE, Mayfield Il, et al. The effect of an education program on the incidence of central venous catheter-associated bloodstream infection in a medical ICU. *Chest* 2004; 126:1612-18.
13. Marschall J, Mermel LA, Fakih M, et al. Strategies to Prevent Central Line–Associated Bloodstream Infections in Acute Care Hospitals:2014 Update. *Infect Cont Hosp Epidemiol* Vol. 2014; 35(7):753-771. http://www.jstor.org/stable/10.1086/676533 [Accessed 10 February 2016]
14. Mermel, L. What is the Predominant Source of Intravascular Infections? *Clin Infect Dis* 2011; 52(2): 211-212.
15. Linares J, Sitges-Serra A, Garau J, et al. Pathogenesis of catheter sepsis: a prospective study with quantitative and semi-quantitative cultures of catheter hub and segments. *J Clin Microbiol* 1985; 21:357-60.
16. Marchaim D, Zaidenstein R, Lazarovitch T, et al. Epidemiology of bacteraemia episodes in a single center: increase in Gram-negative isolates, antibiotics resistance, and patient's age. *Eur J Clin Microbiol Infect Dis* 2008; 27:1045-51
17. Dudeck, Margaret A. et al. National Healthcare Safety Network report, data summary for 2013, Device-associated Module. *Am J Infect Control* 43; 3: 206 - 221
18. Trautmann M, Zauser B, Wiedeck H, et al. Bacterial colonization and endotoxin contamination of intravenous infusion fluids. *J Hosp Infect* 1997; 37:225-36.
19. Gorski L, et al. Infusion Therapy Standards of Practice. *J Infusion Nurs* 2016; 39(1 Supp):S5.
20. Parenti CM, Lederle FA, Impola CL, Peterson LR. Reduction of unnecessary intravenous catheter use: internal medicine house staff participate in a successful quality improvement project. *Arch Intern Med*

1994; 154:1829-32.

21. 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.
22. Hu KK, Lipsky BA, Veenstra DL, Saint S. Using maximum sterile barriers to prevent central venous catheter-related infection: a systematic evidence–based review. *Am J Infect Control* 2004, 32:142-6.
23. Institute for Healthcare Improvement. *How-to Guide: Prevent Central Line-Associated Bloodstream Infections*. Cambridge, MA: Institute for Healthcare Improvement; 2012. http://www.ihi.org/resources/Pages/Tools/HowtoGuidePreventCentralLineAssociatedBloodstreamInfection.aspx [Accessed 10 February 2016]
24. Centers for Disease Control and Prevention. *Checklist for the Prevention of Central Line Associated Bloodstream Infections*. http://www.cdc.gov/HAI/pdfs/bsi/checklist-for-CLABSI.pdf [Accessed 10 February 2016]
25. National Resource for Infection Control. Saving Lives - High Impact Interventions. http://webarchive.nationalarchives.gov.uk/20120118164404/hcai.dh.gov.uk/whatdoido/high-impact-interventions/ [Accessed 10 February 2016]
26. Queensland Department of Health. *Procedure Compliance Checklist: Peripheral Intravenous Catheter (PIVC).* https://www.health.qld.gov.au/clinical-practice/guidelines-procedures/diseases-infection/infection-prevention/intravascular-device-management/default.asp [Accessed 10 February 2016]
27. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR, the Hospital Infection Control Practices Advisory Committee. Guideline for the prevention of surgical site infection, 1999. *Infect Control Hosp Epidemiol* 1999; 20:[247-280].
28. Darouiche RO, Raad II. Prevention of catheter-related infections: the skin. *Nutrition* 1997; 13: 26S-29S.

Published by the International Federation Of Infection Control
47 Wentworth Green
Portadown, BT62 3WG, N Ireland, UK
www.theific.org

Table 17.1. Major sources of contamination related to intravascular catheters

Main source of infection	Prevention
Infusion fluid	If produced in house: • Monitor sterilisation process. • Ensure fluid is pyrogen free. Avoid damage to container during storage. Inspect container for cracks, leaks, cloudiness, and particulate matter.
Addition of medications	Use aseptic technique (hand disinfection, no touch technique). Use sterile medications only. Carry out procedure preferably in the pharmacy. Use a sterile device for accessing the system. Use single-dose vials whenever possible. If multidose vials have to be used: • Refrigerate after opening (if not otherwise recommended by manufacturer). • Wipe diaphragm with 70% isopropanol before inserting a cannula/needle.
Warming-container	Ensure no contamination from warming fluid. Dry warming systems are preferred.
Insertion of catheter	Thorough hand disinfection and use of sterile gloves by operator. Thoroughly disinfect the skin insertion site.
Catheter site	Cover with sterile dressing as soon as possible. Remove catheter if signs of infection occur. Inspect site every 24 hours. Change dressing only when soiled, loosened or wet/damp, using good aseptic technique. Do not use antimicrobial ointments.
Injection ports	Clean with 70% isopropanol and allow to dry before use. Close ports that are not needed with sterile stopcocks.
Changing of infusion set	Replace no more frequently than 72 hours (blood and lipids every 24 hours*). Thorough hand disinfection by operator.

* In some countries, national guidelines or recommendations exist for infusion of blood or blood products, including infusion times of <24 hours. Certain lipid products may also require more frequent replacement.[28]