

Annotated Bibliography

1. **Berenholtz SM, Pronovost PJ, Lipsett PA, et al. Eliminating catheter-related bloodstream infections in the intensive care unit. *Critical Care Medicine*. 2004; 32(10):2014-2020.**

A 1998-2002 prospective cohort study found that the implementation of five interventions reduced the catheter-related bloodstream infection (CRBSI) rate in the study intensive care unit (ICU) from 11.3/1,000 catheter-days to 0/1,000 catheter-days. The control ICU CRBSI rate decreased from 5.7/1,000 catheter-days to 1.6/1,000 catheter-days ($p = 0.56$). The five interventions included implementing an educational intervention to increase staff awareness of evidenced-based infection control practices, creating a catheter insertion cart, asking providers daily whether catheters could be removed, implementing a checklist to ensure adherence to evidenced-based guidelines for preventing CRBSIs, and empowering nurses to stop the catheter insertion procedure if guidelines were not followed. The author reports that the interventions provide a simple, inexpensive process to ensure adherence to evidenced-based guidelines for CRBSI.

2. **Garnacho-Montero J, Aldabo-Pallas T, Palomar-Martinez M, et al. Risk factors and prognosis of catheter-related bloodstream infection in critically ill patients: a multicenter study. *Intensive Care Medicine*. 2008; 34:2185-2193.**

A 2004-2005 prospective, observational, multicenter study assessed the risk factors and prognosis associated with catheter-related bloodstream infections (CR-BSI). The intensive care units of nine Spanish hospitals followed a standardized protocol for central venous catheter insertion and care and followed these patients ($n=1,366$) until discharge or death. The overall incidence of CR-BSI was 3.15 per 1,000 catheter days. Peripherally inserted central venous catheter had a CR-BSI incidence of 1.07 per 1,000 catheter days while central venous catheters had a CR-BSI incidence of 3.73 per 1,000 catheter days. Independent risk factors associated with CR-BSI were duration of catheterization, tracheostomy, and change over a guide wire. Use of a peripherally inserted central venous catheter was a protective factor. Of those patients diagnosed with CR-BSI ($n=66$), 18 died in the ICU (27.3%) while in-hospital mortality was 33.3%. APACHE II score was an independent determinant of in-hospital mortality while early removal of the central venous catheter was a protective factor. This study identifies protective factors, risk factors, and predictors of mortality associated with CR-BSI. This information can be utilized in future CR-BSI prevention programs for critically ill patients.

- 3. Goetz AM, Wagener MM, Miller JM, Muder RR. Risk of infection due to central venous catheters: effect of site of placement and catheter type. *Infection Control and Hospital Epidemiology*. 1998; 19(11):842-845.**

A 1993-1995 prospective, convenience sample study of 300 consecutive central venous catheter insertions of patients on medical-surgical wards at a Veterans' Affairs Medical Center measured the effect of site of placement and catheter type on central venous catheter infections. Catheter contamination was associated with insertion at a femoral site ($p=0.0001$). There was no association between infection and use of a triple-lumen catheter. This study seeks to understand the risks factors associated with central venous catheter infections in patients outside of intensive care units.

- 4. 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.**

A 1986-1987 prospective, randomized trial of 668 patients with who received a central venous or arterial catheter in a surgical intensive care unit evaluated the use of 2% aqueous chlorhexidine-gluconate, 10% povidone-iodine, or 70% alcohol disinfection of the site prior to insertion of the catheter to prevent the development of infection associated with the catheter. Two hundred twenty-seven patients were randomized to the 10% povidone-iodine group, 227 patients to the 70% alcohol group, and 217 patients to the 2% aqueous chlorhexidine-gluconate group and followed until catheter removal. The chlorhexidine group catheter-related infections were 2.3/100 catheter compared to 7.1/100 catheters in the alcohol group and 9.3/100 catheters in the povidone-iodine group ($p=0.02$). This study highlights the effectiveness of chlorhexidine over povidone-iodine and alcohol for disinfection of the site prior to catheter insertion.

- 5. Marschall J, Mermel LA, Classen D, et al. Strategies to prevent central line-associated bloodstream infections in acute care hospitals. *Infection Control and Hospital Epidemiology*. 2008; 29 (supp. 1):S22-S30.**

These practice recommendations were prepared by the Society for Healthcare Epidemiology of America/Infectious Diseases Society of America to provide practical recommendations to acute care hospitals in implementing a central line-associated bloodstream infection (CLABSI) program. The areas of focus include the rationale for implementing a program; strategies to detect and prevent CLABSI; best practices for prevention and monitoring including before insertion, at insertion, and after insertion; special approaches for preventing CLABSI when CLABSI rates are high despite utilizing the basic recommendations; approaches that are not considered part of routine CLABSI prevention; unresolved issues; and performance measures. These recommendations for acute care hospitals provide a concise format to implement and prioritize CLABSI prevention efforts.

6. Mermel LA. Prevention of intravascular catheter-related infections. *Annals of Internal Medicine*. 2000; 132(5):391-402.

A review and meta-analysis was conducted on the prevention of intravascular catheter-related infections. Studies that met the following criteria were included: prospective and randomized, catheters were not inserted over a guide wire, catheter cultures were performed using semi-quantitative or quantitative methods, and catheter related blood stream infections were confirmed using microbial growth from percutaneously drawn blood cultures that matched catheter cultures. Grade one recommendations included avoiding routine replacement of central venous catheters, using chlorhexidine-silver sulfadiazine-impregnated short-term central venous catheters, and using low-dose heparin for patients with short-term central venous catheters.

7. O'Grady NP, Alexander M, Dellinger P, et al. Guidelines for the prevention of intravascular catheter-related infections. *Infection Control and Hospital Epidemiology*. 2002; 23(12):759-769.

These guidelines were prepared by a working group of professionals representing critical care medicine, infectious diseases, infection control, surgery, anesthesiology, interventional radiology, pulmonary medicine, pediatrics, and nursing to reduce the incidence of intravascular catheter-related bloodstream infections (CRBSI). The areas of recommendation include health-care worker education and training, surveillance, hand hygiene, using maximum sterile barrier precautions, using 2% chlorhexidine as the preferred antiseptic, avoiding routine catheter replacement, and utilizing antibiotic impregnated devices in special circumstances. These guidelines aim to reduce the incidence of CRBSI, improve outcomes, and reduce costs that are associated with these infections.

8. Pittet D, Tarara D, Wenzel RP. Nosocomial bloodstream infections in critically ill patients: excess length of stay, extra costs, and attributable mortality. *Journal of the American Medical Association*. 1994; 271(20):1598-1601.

A 1988-1990 case-controlled study in a surgical intensive care unit of a tertiary care institution measured the excess length of stay, extra costs, and mortality that were attributable to nosocomial bloodstream infections in the critically ill. Patients with nosocomial bloodstream infections length of stay was increased by 24 additional days, including 8 extra days in the surgical intensive care unit, when compared to patients who did not have a nosocomial bloodstream infection. Additional costs of \$40,000 per survivor were attributable to nosocomial bloodstream infections. Nosocomial bloodstream infections had an attributable mortality rate of 35%. This analysis can be utilized in future studies to understand the benefits of developing new therapy aimed at reducing nosocomial bloodstream infections.

- 9. Pronovost PJ, Needham D, Berenholtz S, et al. An intervention to decrease catheter-related bloodstream infections in the ICU. *The New England Journal of Medicine*. 2006; 355(26):2725-2732.**

A 2003-2005 prospective cohort study reduced the incidence of catheter-related bloodstream infections (CRBSI) in intensive care units (ICUs) in Michigan from a median rate of 2.7/1,000 catheter-days to a median rate of 0/1,000 catheter-days in 3 months. The mean rate was reduced from 7.7/1,000 catheter-days at baseline to 1.4/1,000 catheter-days at 16-18 months. This study included 85% (n=1,625) of all ICU beds in Michigan, included teaching and non-teaching hospitals as well as small hospitals (<200 beds) and large hospitals (≥200 beds). The final analysis included 375,757 catheter-days. The interventions aimed at reducing CRBSIs were educating clinicians, implementing a central line cart, utilizing a checklist to ensure adherence to infection control practices, stopping the provider when infection control practices were not followed, asking providers daily whether the catheter could be removed, and giving teams feedback on their number and rates of CRBSIs.

- 10. Raad II, Hohn DC, Gilbreath BJ, et al. Prevention of central venous catheter-related infections by using maximal sterile barrier precautions during insertion. *Infection Control and Hospital Epidemiology*. 1994; 15(4 Pt 1):231-238.**

A 1991 prospective, randomized, control study of 343 patients who received a central venous catheter evaluated the use of maximum sterile precautions (mask, cap, sterile gloves, gown, and large drape) compared to control precautions (sterile gloves and small drape) to prevent the development of central venous catheter-related infections. One hundred seventy six patients were randomized to the maximum sterile precautions group and 167 patients to the control precautions group, these patients were followed for 3 months or until catheter removal whichever came first. The patients were comparable in underlying disease, degree of immunosuppression, therapeutic interventions, and catheter risk factors for infections. Four patients developed catheter-related infections in the maximum sterile precautions group compared to 12 catheter-related infections in the control precautions group (p=0.03). The colonization rate was 1/1,000 catheter-days in the control precautions group compared to 0.3/ 1,000 catheter-days in the maximum sterile precautions group (p=0.007). This study highlights the effectiveness of maximum sterile precautions in the prevention of central venous catheter-related infections.

- 11. Shannon RP, Patel B, Cummins D, Shannon AH, Ganguli G, Lu Y. Economics of central line-associated bloodstream infection. *American Journal of Medical Quality*. 2006; 21(7):7S-16S.**

A 2002-2005 prospective, longitudinal study measured the economic impact of central line-associated bloodstream infections (CLABSI) and the complications related to the infections in 2 intensive care units. Fifty-four central line infections resulted in a gross

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margin (payment – expense) of -\$26,839 per case. A small nested case-control design (5 cases matched to 5 controls) was used to compare revenues, expenses, and net operating margins in cases with and without CLABSI. These cases were matched for age, severity of illness on admission, and principal diagnosis. Costs attributable to the central line infection and its complications averaged 43.8% of the total expenses. This economic analysis revealed that patients, payers, and hospitals do not benefit from these complications.