Analysis of central venous catheter utilization at a quaternary care hospital

Graham Aufricht^a, Joseph Hoang^a, Jose Iglesias^a, Heidi Latiolais^a, Hollie Sheffield^a, Cristian Trejo^a, Max Holder, BSN, RN, CRNI, CEN, VA-BC^b, Susan Smith, DNP, RN, ACNS-BC^c, John Garrett, MD^{a,d}, and Cristie Columbus, MD^{a,e}

^aCollege of Medicine, Texas A&M University, Dallas, Texas; ^bIV Services, Baylor University Medical Center, Dallas, Texas; ^cDepartment of Nursing Education, Baylor University Medical Center, Dallas, Texas; ^dDepartment of Emergency Medicine, Baylor University Medical Center, Dallas, Texas; ^eDivision of Infectious Diseases, Department of Internal Medicine, Baylor University Medical Center, Dallas, Texas

ABSTRACT

Central line–associated bloodstream infections (CLABSI) are one of the most dangerous and costly types of hospital-acquired infections. Incidence of CLABSI can be significantly reduced through proper aseptic techniques, surveillance, and active management strategies, including elimination of idle central line days. This quality improvement project examined two central venous catheter (CVC) cohorts. The institutional electronic health record (EHR) was utilized to generate a daily report indicating CVC utilization by patient care unit. The EHR was further scrutinized for documentation of appropriate indications for CVC use employing an appropriateness tool developed by the institutional vascular access team. Cohort 1 included 12 National Healthcare Safety Network–reportable units audited on a daily basis over a 4-week time period; cohort 2 included selected National Healthcare Safety Network–nonreportable units audited on a daily basis over a 2-week time period. Central venous catheters that did not meet defined indications as outlined by the institutional vascular access team’s data collection checklist were escalated the same day to the unit clinical nurse manager for review and possible removal. The percentage of clinically nonindicated CVCs in cohort 1 fell by 65% over the 4-week period of daily audit and real-time feedback, with similar results noted for cohort 2. In conclusion, real-time audit and feedback regarding appropriate clinical indications for CVC use can result in decreased idle or nonindicated central line days, potentially contributing to decreased CLABSI rates.

KEYWORDS Central line; central line–associated bloodstream infection; central venous catheter; hospital-acquired infection; peripherally inserted central catheter; real-time audit and feedback; utilization rates

A central line–associated bloodstream infection (CLABSI) is a laboratory-confirmed bloodstream infection in the presence of an indwelling central venous catheter (CVC) within 48 hours of the bloodstream infection, unrelated to infection at another site.¹ These are among the most dangerous and costly types of nosocomial infections,² with an estimated incidence of 35,800 cases in 2014,³ estimated mortality up to 25%,⁴ and estimated additional cost of \$46,000 per case.¹

CVCs can be implanted either centrally or peripherally⁵ and can become infected by multiple routes,⁶ both intraluminal and extraluminal.⁷ A variety of host factors increase the risk of CLABSI, including immune compromise, chronic

illness, extremes of ages, malnutrition, total parenteral nutrition, catheter type, site of insertion (with the femoral site considered highest risk), loss of skin integrity, and prolonged hospital stay prior to line insertion.^{8,9}

Gram-positive organisms are the most common pathogens, though gram-negative organisms and *Candida* species are also reported.¹⁰ Prevention strategies include adherence to Centers for Disease Control and Prevention guidelines during CVC insertion, maintaining appropriate aseptic technique when accessing CVCs, and removing CVCs when no longer indicated. The Centers for Disease Control and Prevention also recommends daily audits to assess continued line necessity.¹¹

Corresponding author: Cristie Columbus, MD, Division of Infectious Diseases, Baylor University Medical Center, 3500 Gaston Ave., Dallas, TX 75246 (e-mail: Cristie.Columbus@BSWHealth.org)

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Table 1. Institutional vascular access team indications for central lines

Indications for central line use

Antibiotic therapy administration for >14 days
Hemodynamic monitoring
Total parenteral nutrition
Vesicant cytotoxic therapy
Intravenous therapy administration for >30 days
Vancomycin administration for >7 days
Intravenous therapy requiring central venous access device for administration
Complex drug regimen (≥ 2 intravenous medications)

METHODS

This quality improvement project was performed over a total of 6 weeks, and data were collected and evaluated from two separate cohorts. The hospital units evaluated consisted of both intensive care units and various inpatient medical-surgical units. CVCs included in the audit were tunneled and nontunneled CVCs, dialysis catheters, peripherally inserted central catheter (PICC) lines, pulmonary artery catheters, and vascular access ports. Cohort 1 consisted of 12 separate medical-surgical and intensive care units and was evaluated during the first 4 weeks. Each day, approximately 62 separate CVCs were evaluated for appropriate indications and dwell time. Following the evaluation of the first cohort, a second cohort was evaluated, which consisted of 11 different medical-surgical and intensive care units. Cohort 2 was evaluated for 2 weeks; during this period, approximately 74 separate CVCs were evaluated daily for appropriate indications and dwell time.

The institutional data audit and reporting function within the electronic health record (EHR, Allscripts) was utilized to create a daily report of CVCs on the selected hospital units. These CVCs were then audited prospectively for line necessity from the EHR and provider documentation. The institutional vascular access team had developed a list of CVC indications adapted from the Michigan Appropriateness Guide for Intravenous Catheters guidelines⁵ (Table 1). CVCs that did not meet these defined indications were escalated the same day to the unit clinical nurse manager for review and possible removal.¹² Once the unit clinical nursing manager reviewed the audit results, line necessity was discussed with the patient's provider. Responses were recorded as "indicated" after discussion with the provider and clarification and documentation of the appropriateness of the indication, "nonindicated" if the CVC was removed after query, or "no response" if neither clinical justification nor removal was documented. Outcomes of no response were excluded from further analysis. Statistical analysis was performed using a chi-square test for trend in proportions using R Statistical Software Version 3.2.3 (R Foundation for Statistical Computing, Vienna, Austria).

Figure 1. Representation of change in nonindicated central venous catheters in both cohorts.

RESULTS

In the first cohort of patients, 1239 CVCs were evaluated over a 4-week period. The percentages of clinically nonindicated CVCs over the first 4 weeks of review and intervention were 4.04%, 3.54%, 3.47%, and 1.40%, respectively. This represents a 65.4% decrease from week 1 to week 4 ($P = 0.02$). The subsequent 2-week project including the evaluation of 744 CVCs was performed involving cohort 2. The percentage of clinically nonindicated lines in this cohort decreased from 4.08% to 1.22%. This represents an overall decrease of 70.1% for the 2-week period ($P = 0.035$) (Figure 1).

DISCUSSION

Although multiple studies have correlated CVC dwell time and CLABSI rates in the neonate and pediatric populations, limited data exist in adults, especially regarding concurrent audit of central line utilization. In a study by Fisher et al,¹³ CLABSI rates decreased by 71% across 13 neonatal intensive care units, with statistically significant sustainment 1 year later, following frequent CVC insertion and maintenance reporting. Another study by Milstone et al¹² evaluated the risk of developing CLABSIs as a function of PICC dwell time. This study concluded that the average predicted daily risk of CLABSIs after PICC insertion increased during the first 2 weeks after PICC insertion and remained elevated for the entirety of dwell time of the catheter. The authors ultimately suggested that clinicians should review PICC necessity daily. Sengupta et al¹⁴ and Advani et al¹⁵ also supported this trend in the neonatal intensive care unit and pediatric settings, suggesting that catheter duration is an important risk factor for development of PICC-associated CLABSIs. The current study involved concurrent audit and real-time feedback regarding CVC necessity in an adult population in an inpatient setting to ensure that appropriate indications for CVC use were observed, with the aim of reducing the incidence of nonindicated CVCs and potentially ultimately decreasing CLABSI rates.

In the two cohorts of patients with CVCs, the use of real-time audit and feedback was associated with a substantial decrease in clinically nonindicated CVCs. With the prompt removal of nonindicated CVCs, the goal was to decrease

inappropriate CVC line days. If decreased line days resulted in decreased CLABSI rates, this would be expected to improve patient care by decreasing length of stay and additional costs associated with treatment of CLABSIs. One study reported that length of stay was increased by an average of 3 weeks when a patient acquired a CLABSI.² Reducing CLABSIs also provides benefits to the institutions that would otherwise experience revenue losses. The rate of CLABSIs among hospital intensive care units has been reduced 58% from 2001 to 2009, which correlates with savings of \$414 million.¹⁶

In recent years, many preventive actions have been taken to reduce hospital-acquired infections; however, no single measure has successfully eliminated all CLABSIs. The Centers for Disease Control and Prevention estimates that approximately 80,000 CLABSIs occur in the USA each year. Furthermore, recent data suggest that risk of mortality is increased by 25% among patients with a CLABSI.¹⁷ Appropriate dressing, skin care, flushing lines, tubing changes, hand hygiene, insertion site selection, and timely removal of unnecessary lines have contributed to reduced rate of infections. Line necessity and CLABSI rates can be further reduced by implementing maintenance bundles. The Institute for Healthcare Improvement describes a bundle as a structured way to improve the process and outcomes of patient care through evidence-based practices, and this organization provides a CLABSI-specific guideline that covers various interventions and strategies for prevention.¹⁸ Studies have shown that utilizing a checklist integrated in the EHR increases daily documentation of line necessity by providers and lowers CLABSI rates.¹⁷ A checklist facilitates daily, real-time auditing of central lines and reduces variation while increasing compliance with line maintenance best practices by including components such as hand hygiene, dressing change, and tubing change as part of the bundle. A study found that 22% of CLABSIs in a surgical intensive care unit were not medically indicated, providing more evidence that enacting a set of guidelines for appropriate central line indications can help decrease line utilization.¹⁹

The implementation of a clear guideline for appropriateness of CVC use was essential for the success of the quality improvement intervention. Having clearly defined CVC indications enabled real-time audit of CVCs in the institution and, subsequently, real-time feedback to the care teams regarding potentially nonindicated CVCs. This project provides evidence that concurrent audit and real-time feedback are important components for limiting idle line days. Most nonindicated CVCs had indeed been indicated upon insertion but were no longer indicated as the hospital course progressed, resulting in unnecessary dwell days. Providing the care team with education about the increased risk of a CLABSI from maintaining a line that is no longer necessary is an important aspect of preventing CLABSIs through real-time feedback.

This project had several limitations. Knowing the effects of this project on actual CLABSI rates could potentially strengthen the results and provide evidence of the benefit of implementing concurrent auditing and real-time feedback. Immediately preceding the implementation of this project, several other interventions were introduced surrounding reduction of CLABSI incidence, including trial periods of different types of dressings, various antimicrobial products, and staff re-education and awareness efforts. Additionally, because the two utilization audit/feedback intervention periods were brief, assessment of ultimate impact upon CLABSI rates would require a longer period of intervention and data collection, preferably compared to a similar period without intervention, ideally without the coincident/recent introduction of other interventions to reduce CLABSI incidence. Moreover, the Hawthorne effect resulting from the knowledge that CVC appropriateness criteria were being externally audited cannot be ruled out; a subsequent project will evaluate rates after the intervention period has concluded. Further studies are needed to provide additional evidence of the benefit of concurrent audit and real-time feedback on CVC utilization rates, idle line days, and potential cost savings surrounding their reduction, as well as decreased incidence of CLABSI.

In conclusion, preventing CLABSIs reduces health care costs and improves quality of care. Concurrent audit with real-time feedback regarding CVC necessity correlated with a reduction in clinically nonindicated lines. This demonstrates one promising method for improving central line utilization and potentially reducing the incidence of CLABSIs. Further surveillance is needed to ensure that adherence to appropriate indication criteria is hard-wired for CVCs placed in the future. Proposed interventions aimed at eliminating unnecessary CVCs include educating health care providers on proper CVC indications and integrating an EHR that requires daily justification for CVC use. Implementing a multifaceted approach of daily audit that includes not only line necessity but also observed aseptic techniques for maintenance of catheters can improve CLABSI rates by involving the nursing/allied health providers who manage CVCs.

ORCID

Cristie Columbus <http://orcid.org/0000-0001-5859-4786>

1. Haddadin Y, Regunath H. Central line associated blood stream infections (CLABSI). March 2017. <https://www.ncbi.nlm.nih.gov/books/NBK430891/>. Accessed April 27, 2018.
2. Latif A, Halim MS, Pronovost PJ. Eliminating infections in the ICU: CLABSI. *Curr Infect Dis Rep*. 2015;17(7):491. doi:10.1007/s11908-015-0491-8.
3. Centers for Disease Control and Prevention. 2016 National and state healthcare-associated infections progress report: data tables. <https://www.cdc.gov/hai/data/portal/progress-report.html>. Accessed June 28, 2018.

4. O'Grady NP, Alexander M, Dellinger EP, et al. Centers for Disease Control and Prevention guidelines for the prevention of intravascular catheter-related infections. *MMWR Recomm Rep*. 2002;51(RR-10): 1–29.
5. Chopra V, Flanders SA, Saint S, et al; Michigan Appropriateness Guide for Intravenous Catheters (MAGIC) Panel. The Michigan Appropriateness Guide for Intravenous Catheters (MAGIC): results from a multispecialty panel using the RAND/UCLA appropriateness method. *Ann Intern Med*. 2015;163(6):S1–S40. doi:10.7326/M15-0744.
6. Centers for Disease Control and Prevention. Infection control. <https://www.cdc.gov/infectioncontrol/guidelines/bsi/background/pathogenesis.html>. Published September 27, 2016. Accessed June 28, 2018.
7. Gahlot R, Nigam C, Kumar V, Yadav G, Anupurba S. Catheter-related bloodstream infections. *Int J Crit Illn Inj Sci*. 2014;4(2): 162–167. doi:10.4103/2229-5151.134184.
8. Marschall J, Mermel LA, Fakih M, et al; Society for Healthcare Epidemiology of America. Strategies to prevent central line-associated bloodstream infections in acute care hospitals: 2014 update. *Infect Control Hosp Epidemiol*. 2014;35(07):753–771. doi:10.1086/676533.
9. Parienti JJ, Mongardon N, Mégarbane B, et al; 3SITES Study Group. Intravascular complications of central venous catheterization by insertion site. *N Engl J Med*. 2015;373(13):1220–1229. doi:10.1056/NEJMoa1500964.
10. Weiner LM, Webb AK, Limbago B, et al. Antimicrobial-resistant pathogens associated with healthcare-associated infections: summary of data reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2011–2014. *Infect Control Hosp Epidemiol*. 2016;37(11):1288–1301. doi:10.1017/ice.2016.174.
11. Centers for Disease Control and Prevention. Checklist for prevention of central line associated blood stream infections. <https://www.cdc.gov/hai/pdfs/bsi/checklist-for-CLABSI.pdf>. Published 2011. Accessed June 26, 2018.
12. Milstone AM, Reich NG, Advani S, et al. Catheter dwell time and CLABSI in neonates with PICCs: a multicenter cohort study. *Pediatrics* 2013;132(6):e1609–e1615. doi:10.1542/peds.2013-1645.
13. Fisher D, Cochran KM, Provost LP, et al. Reducing central line-associated bloodstream infections in North Carolina NICUs. *Pediatrics*. 2013;132(6):e1664–e1671. doi:10.1542/peds.2013-2000.
14. Sengupta A, Lehmann C, Diener-West M, Perl TM, Milstone AM. Catheter duration and risk of CLA-BSI in neonates with PICCs. *Pediatrics*. 2010;125(4):648–653. doi:10.1542/peds.2009-2559.
15. Advani S, Reich NG, Sengupta A, Gosey L, Milstone AM. Central line-associated bloodstream infection in hospitalized children with peripherally inserted central venous catheters: extending risk analyses outside the intensive care unit. *Clin Infect Dis*. 2011;52(9): 1108–1115. doi:10.1093/cid/cir145.
16. Liang SY, Marschall J. Update on emerging infections: news from the Centers for Disease Control and Prevention. Vital signs: central line-associated blood stream infections—United States, 2001, 2008, and 2009. *Ann Emerg Med*. 2011;58(5):447–451. doi:10.1016/j.annemergmed.2011.07.035.
17. Pageler NM, Longhurst CA, Wood M, et al. Use of electronic medical record-enhanced checklist and electronic dashboard to decrease CLABSI. *Pediatrics*. 2014;133(3):e738–e746. doi:10.1542/peds.2013-2249.
18. Institute for Healthcare Improvement. *How-to Guide: Prevent Central Line-Associated Bloodstream Infection*. Cambridge, MA: Institute for Healthcare Improvement; 2012.
19. Rotz S, Sopirala MM. Assessment beyond central line bundle: audits for line necessity in infected central lines in a surgical intensive care unit. *Am J Infect Control*. 2012;40(1):88–89. doi:10.1016/j.ajic.2011.06.004.