Catheter-Associated Bloodstream Infections in the NICU: Getting to Zero

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Abstract

The neonatal population is at a particularly high risk for catheter-associated bloodstream infections (CABSI). Chlorhexidine for skin antisepsis is well documented to effectively decrease the incidence of bloodstream infections associated with central venous catheters in other populations. The project described in this article demonstrates that chlorhexidine for central venous catheter insertion and line maintenance in the neonatal population safely and effectively reduces CABSI.

Reducing catheter-associated adverse events by 50 percent was identified as the top health care safety priority for the Centers for Disease Control in 2005.[1] Neonates, especially those of low and very low birth weight, are at particularly high risk for infection due to their compromised immune status. Central venous catheters (CVCs) are often necessary to administer intravenous fluids and medications, but their insertion and use are not without risk. The most common complication is bloodstream infection, which occurs at rates of 3.1–6.4 per 1,000 CVC days in NICUs according to the National Healthcare Safety Network (NHSN).[2]

Procedures to minimize the occurrence of catheter-associated bloodstream infections (CABSIs) are an important issue. The Institute for Healthcare Improvement (IHI), a nonprofit organization that focuses on health care improvement, as part of the national Protecting 5 Million Lives from Harm campaign, identified a bundle of best practice measures to aid in the reduction of CABSI.[3] Bundling groups of best practices, as in this case with central lines, has been shown to result in better outcomes than implementing them individually. The components of the bundle include the use of maximum sterile barrier precautions for line insertion, optimal hand hygiene practices, daily assessment of the need for a CVC, and the use of chlorhexidine gluconate (CHG) for skin antisepsis.

The most common mechanism of a CABSI is migration of the infectious organism from the insertion site of the catheter and colonization at its distal end. Organisms that typically cause CABSI are coagulase negative staphylococci, *Staphylococcus aureus*, and Enterobacteriaceae.[4] The most common organism related to CABSI in our NICU during 2007 was coagulase negative staphylococci, specifically *S. epidermidis*, accounting for 38 percent of all CABSIs.

Our NICU at Arkansas Children's Hospital is an 85-bed Level IV regional referral center that averages 800 admissions per year. The average daily census in 2003 was 54, which has increased to 80 in 2008. All admissions to the unit are transported to the facility because obstetric services are not available in-house. Infants are managed by a team of neonatologists, neonatal nurse practitioners (NNPs), neonatal fellows, and pediatric residents. The primary CVCs that are used include peripherally inserted central catheters (PICCs) and Broviac catheters. The PICCs are 26 gauge and 28 gauge L-Caths (Becton-Dickinson, Sandy,Utah) that are inserted by the NNPs. Broviac catheters are used primarily for patients with gastrointestinal surgical diagnoses who will require long-term

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TABLE 1 ■ NICU CABSIs

Time Period	Total Patients with CVCs	Average Birth Weight Risk Stratification	Mean Duration of Catheter	Total Number of CABSIs	Rate of Infection
2007	n = 470 PICC = 414 Broviac = 56	PICC = 27% <1,000 g Broviac = 15% <1,000 g	PICC = 17 days Broviac = 56 days	PICC = 14 Broviac = 7	PICC = 1.7/1,000 catheter days Broviac = 3.3/1,000 catheter days
2008	n = 263 PICC = 240 Broviac = 23	PICC = 22% <1,000 g Broviac = 9% <1,000 g	PICC = 16 days Broviac = 34 days	PICC = 2 Broviac = 0	PICC = 0.5/1,000 catheter days Broviac = 0

hyperalimentation therapy. These are tunneled catheters that are placed by the general surgery team in the operating room. In 2007, 388 PICCs were placed, 26 patients were admitted with PICCs from referring hospitals, and 56 Broviacs were inserted (Table 1).

The literature supports the use of CHG for skin antisepsis.[5] However, its use in the neonatal population has received limited attention. At our institution, the pediatric intensive care unit (PICU) implemented the IHI best practices bundle for the prevention of CABSI (Table 2). Between 1997 and 2005, annual CABSI rates decreased from 9.7 to 3 per 1,000 catheter days.[6]

QUALITY IMPROVEMENT INITIATIVE METHODS

This quality improvement project (internal review board exempt) extended part of the IHI bundle to the neonatal population by introducing CHG (alcohol-based) as a skin antisepsis and a CHG impregnated patch (Biopatch, Johnson & Johnson Gateway, Piscataway, New Jersey) around the catheter insertion site to provide an additional antimicrobial barrier. Beginning in 2003, a series of best practice measures was implemented in the NICU, including the optimal use of hand hygiene and the use of maximum sterile barrier precautions during line insertion (Table 3). In 2004, a dedicated CVC team of NNPs and expert bedside nurses was appointed to be responsible for the insertion of PICCs and proactive management of all CVCs. Proactive management included weekly data collection of insertion date, birth weight, parenteral infusion/medications, dressing site evaluation, line complications, line necessity, and the date when the line is discontinued. As part of the team, the Infection Control Department collects the denominator data and identifies bloodstream infections according to the NHSN definitions. Infection rates are calculated based on this information with the following formula:

$$\frac{\text{Total no. of CABSI cases}}{\text{No. of catheter days}} \times 1{,}000 = \text{CABSI rate per 1,000 catheter days}$$

LINE INSERTION/DRESSING CHANGE PROCEDURE

The implementation of CHG for skin antisepsis began in March 2006. Initially, because of concerns related to the integrity of premature skin, CHG was used for skin antisepsis for the insertion of PICCs and dressing changes in all CVCs, including PICCs and Broviacs for infants weighing more than 2,000 g or who were greater than two weeks of age.

The Biopatch was placed on all patients with Broviac catheters. Broviac dressings are changed weekly in coordination with the Biopatch changes. A randomized trial of the Biopatch concluded, "The patch provides protection against catheter tip colonization. Suppressing catheter site colonization with local antisepsis is an effective means of reducing the risk of CABSI" (p. 1432).[7] The CVC team elected not to place the Biopatch on infants with PICC lines for two reasons:

1. PICC lines are not trimmed. Therefore, the line is curled on the skin, making it difficult to allow the Biopatch to be in direct contact with the skin.

2. Dressing changes occur every two weeks unless the integrity of the dressing has been compromised. According to the manufacturer recommendations, the Biopatch has to be changed every 7 days, requiring more frequent dressing changes and subsequently, a greater risk for dislodgement. The average PICC line duration has been approximately 21 days.

To provide better continuity of care for CVCs, the dedicated CVC team was expanded in August 2006. Two NNPs taught and trained the additional NNPs regarding the use of CHG for PICC placement. These two NNPs also performed the majority of the dressing changes for the Broviac catheters. Also added to the team was a staff registered nurse who served as data collector for CVCs. In addition, this nurse was the staff educator and also served as a primary resource for PICC dressing changes. After six months, no adverse skin conditions were associated with CHG use in the PICC population (weighing more than 2,000 g or greater than two weeks of age). In the Broviac population, 2 of 56 patients developed minor skin irritation with the use of the CHG patch. Because of the rarity of adverse skin conditions, the process was expanded to the population of infants weighing more than 1,000 g or who were greater than two weeks of age. This extension began in September 2006. As of August 2008, there have been no adverse skin conditions noted in this patient population from using CHG for skin antisepsis for line placement and dressing changes.

Two infants with Broviac catheters who required long-term care tolerated the use of CHG for six months, then developed skin irritation around the insertion site. The decision was made to stop the use of CHG and the Biopatch.

TABLE 2 ■ Bundle Comparison

IHI Bundle	NICU Bundle
Hand hygiene	Hand hygiene
Maximal barrier precautions	Maximal barrier precautions
CHG skin antisepsis	CVC team
Optimal catheter site selection changes	CHG skin antisepsis/dressing
Daily review of line necessity	Biopatch
	Masks with dressing changes
	CHG for line maintenance

TABLE 3 ■ Time Line for CABSI Initiative

September 2003	Implemented maximum sterile barrier precautions
February 2004	CVC team initiated
March 2006	CHG for skin antisepsis/dressing changes (patients >2,000 g or >2 weeks)/Biopatch
September 2006	CHG for skin antisepsis/dressing changes (patients >1,000 g or >2 weeks)
March 2007	Began using masks for dressing changes
September 2007	CHG for line maintenance
November 2007	>100 days CABSI free for Broviac patients
July 2008	>100 days CABSI free for PICC patients

One of these infants was able to keep the line in place for 361 days without a CABSI. Toward the end of this infant's hospitalization, the team used the Algidex Ag patch (DeRoyal, Powell, Tennessee) as part of his CVC care regimen. This is a sterile patch that is coated with an ionic silver alginate that provides a broad-spectrum antimicrobial barrier.

Beginning in September 2007, we expanded the use of CHG for skin antisepsis for procedures including bladder taps, insertion of peripheral intravenous catheters, and peripheral arterial lines. We do not use it for umbilical line insertion, ventricular taps, and lumbar punctures because of the manufacturer recommendations. No adverse skin reactions were noted with this extended use of CHG.

LINE MAINTENANCE

In our effort to further reduce CABSI starting in September 2007, the focus expanded to line maintenance. Rizzo has reported, "Contamination of catheter hubs by medical personnel is the most common source of infection for long term catheters. This occurs by introducing the organisms when the catheter is manipulated; these pathogens then migrate intraluminally with the potential of reaching the distal tip in the bloodstream" (p. 217).[1] CHG (3.15 percent) prep pads are used to clean the tubing connection sites and access ports for tubing changes, medication administration, and blood sampling on all CVCs, peripheral intravenous lines, arterial lines, and umbilical lines. All connections are scrubbed for 30 seconds with CHG and allowed to dry prior to accessing the port or line.

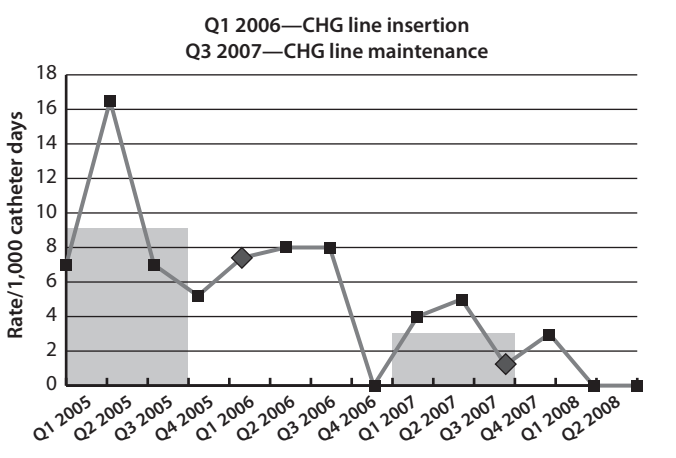
STAFF EDUCATION/MOTIVATION

An important aspect of implementing any change is to actively involve the people participating in this change. Ongoing education and participation of the bedside staff was a priority throughout this project. In addition to formal staff education, informal discussion and information sharing took place on a regular basis. Approximately 18 months into the project, several inservices were held to review the progress achieved. To motivate the staff, a goal was set to reach 100 days between catheter infections. This was accomplished in November 2007, with 117 days between Broviac CABSIs. The CABSI occured in a patient with a vascular tumor who was receiving chemotherapy treatment through the Broviac catheter on a weekly basis. This milestone was celebrated with an ice cream sundae party. At that time, the staff completed a questionnaire that contained eight questions about the implementation of the project in the NICU, the goal being to stimulate their interest and increase ownership in the project. A drawing for several gift cards took place to show appreciation for their continued commitment to this project.

RESULTS

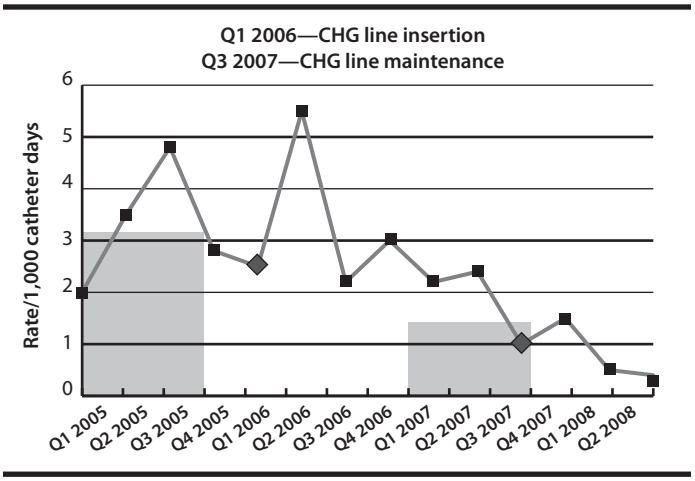
The biggest impact on CABSI was in the patient population who required the use of Broviac catheters. In 2005, there was a total of 20 Broviac CABSIs, for a rate of 9.3 infections per 1,000 catheter days. After beginning the use of CHG for skin antisepsis and line maintenance and use of the CHG-impregnated patch, the number of infections decreased over the next two years to 7 infections during 2007, for a rate of 3.3 infections per 1,000 catheter days (Figure 1). The number of Broviac line days remained steady over this three-year time frame.

FIGURE 1 ■ Broviac CABSIs.



Key: Q = quarter
Shaded areas represent mean number of infections for year.

FIGURE 2 ■ PICC-associated bloodstream infections.



Key: Q = quarter
Shaded areas represent mean number of infections for year.

PICC usage increased from 5,151 line days in 2005 to 8,148 line days in 2007. Despite the increase in line days, the incidence of CABSI in this patient population fell from 21 infections during 2006 to 14 infections during 2007. The infection rate over these three years decreased from 3.1 infections per 1,000 catheter days in 2005 to 1.7 infections per 1,000 catheter days during 2007 (Figure 2). In July 2008, another milestone was reached with 114 days since the last CABSI in the PICC population, surpassing the 63-day record from 2007.

The cost to treat 1 CABSI is estimated to range between $34,508 and $56,000 for an average cost of $45,000.[5] The average number of CABSIs from 2003 to 2007 was 29 per year, for an estimated cost of $1.3 million to treat these infections. The largest reduction in CABSI in this unit occurred after line maintenance with CHG was implemented. For the first seven months in 2008, only 2 CABSIs have occurred, 1 in an oncology patient with leukemia being treated with chemotherapy who developed yeast sepsis and the other in a 34-week gestational age infant who grew *Staphylococcus warneri* from the PICC. The trend for 2008 will drop CABSI incidence to 1 per quarter and save an average of $1.1 million annually. The cost of an alcohol prep pad is 4 cents, and a CHG prep pad costs 12 cents.

CONCLUSION

The success of this five-year project can be attributed to using a multidisciplinary, stepwise approach (see Table 3) similar to the one used in the PICU.[6] This stepwise approach was taken to reduce the CABSI rate in a very fragile population who require frequent and long-term use of central lines.

Success was not immediate, as evidenced by the CABSI rate in PICCs during the second quarter of 2006. Maintaining focus and commitment of the bedside staff was a challenge; however, with perseverance and dedication, substantial reduction in CABSI was achieved. The overall CABSI rate for both Broviacs and PICCs combined for 2007 was 2.1 infections per 1,000 catheter days, down from 4.9 infections per 1,000 catheter days in 2005 even as total line days increased 40 percent, from 7,312 to 10,241.

This project will continue into the future as additional best practice measures are identified and implemented. We intend to make this success sustainable.

Editor's Note: The authors note, that from the time this article was accepted for publication, the NICU has continued to see success with their bloodstream prevention initiative. The overall PICC bloodstream infection rate for 2008 was 0.2 per 1,000 line days. There was a total of 2 PICC-related infections and no Broviac-related line infections for all of 2008. The last Broviac related line infection was in December 2007.

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Sabra Curry received her BS degree in nursing from the University of Arkansas for Medical Sciences in 1990. She worked in the NICU at Arkansas Children's Hospital as a staff nurse and transport nurse until she went to St. John's Mercy Medical Center, St. Louis, Missouri, in 1993 to attend the NNP Certificate Program. She received her master's degree in nursing from the University of Central Arkansas in 1996. She has worked at Arkansas Children's Hospital in the NICU as an NNP since 1993.

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Sir Francis Bacon, Religious Meditations, Of Heresies, 1597
English author, courtier, & philosopher (1561–1626)

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