Reduction in central line-associated bloodstream infections by implementation of a postinsertion care bundle

Karen Guerin, MSN,[a] Julia Wagner, RN, MS, CCRN,[a] Keith Rains, BSN, CICP,[a] and Mary Bessesen, MD[a,b]
Denver, Colorado

Background: Central line-associated bloodstream infections (CLABSIs) cause substantial morbidity and incur excess costs. The use of a central line insertion bundle has been shown to reduce the incidence of CLABSI. Postinsertion care has been included in some studies of CLABSI, but this has not been studied independently of other interventions.
Methods: Surveillance for CLABSI was conducted by trained infection preventionists using National Health Safety Network case definitions and device-day measurement methods. During the intervention period, nursing staff used a postinsertion care bundle consisting of daily inspection of the insertion site; site care if the dressing was wet, soiled, or had not been changed for 7 days; documentation of ongoing need for the catheter; proper application of a chlorohexidine gluconate-impregnated sponge at the insertion site; performance of hand hygiene before handling the intravenous system; and application of an alcohol scrub to the infusion hub for 15 seconds before each entry.
Results: During the preintervention period, there were 4415 documented catheter-days and 25 CLABSIs, for an incidence density of 5.7 CLABSIs per 1000 catheter-days. After implementation of the interventions, there were 2825 catheter-days and 3 CLABSIs, for an incidence density of 1.1 per 1000 catheter-days. The relative risk for a CLABSI occurring during the postintervention period compared with the preintervention period was 0.19 (95% confidence interval, 0.06-0.63; $P = .004$).
Conclusion: This study demonstrates that implementation of a central venous catheter postinsertion care bundle was associated with a significant reduction in CLABSI in a setting where compliance with the central line insertion bundle was already high.
Key Words: Bacteremia; central venous catheterization; infection control; catheter-related infections; line care bundle.

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Central line-associated bloodstream infections (CLABSIs) are associated with increased lengths of hospital stay and costs as high as $29,000 per episode.[1] The estimated annual cost of CLABSIs to the health care system in the United States is $2.3 billion.[2] Eggimann et al[3] demonstrated that a comprehensive infection control program including meticulous sterile insertion technique and postinsertion care was associated with a 67% reduction in CLABSI incidence at a single center. Building on this work, Pronovost et al[2] performed a multicenter study and found that implementation of a central venous catheter (CVC) insertion bundle was associated with a 66% reduction in CLABSI incidence density. Department of Veterans Affairs hospitals implemented a nationwide CVC insertion bundle and surveillance system on April 1, 2006. At Department of Veterans Affairs Medical Center Denver (DVAMC-Denver), the CLABSI rate remained high during the first 2 years of this program, despite excellent compliance with the CVC insertion bundle. We reviewed each CLABSI case for clues to the continuing high infection incidence density, and then implemented a postinsertion care bundle to address the problem.

From the Department of Veterans Affairs Eastern Colorado Healthcare System, Denver, CO[a]; and Department of Medicine Division of Infectious Diseases, University of Colorado at Denver Health Sciences Center, Denver, CO.[b]

Address correspondence to Mary Bessesen, MD, Infectious Diseases (111L), 1055 Clermont Street, Denver, CO 80220. E-mail: Mary.Bessesen@ucdenver.edu.

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METHODS

Setting

DVAMC-Denver is a university-affiliated acute care teaching hospital with 5000 admissions and 38,000 patient-days per year. It includes a 10-bed medical intensive care unit (MICU) and a 13-bed surgical intensive care unit (SICU), both with a nurse-to-patient ratio of 1:2. Physician staff members are postgraduate residents and faculty of the University of Colorado at Denver School of Medicine.

Table 1. Case definition for CLABSI

Criterion 1: Patient has a recognized pathogen cultured from one or more blood cultures, and the organism cultured from blood is not related to an infection at another site.
Criterion 2: Patient has at least one of fever (>38°C), chills, or hypotension; positive laboratory results are not related to an infection at another site; and common skin contaminant (ie, diphtheroids [*Corynebacterium* spp], *Bacillus* [not *B anthracis*] spp, *Propionibacterium* spp, coagulase-negative staphylococci [including *S epidermidis*], viridans group streptococci, *Aerococcus* spp, *Micrococcus* spp) is cultured from 2 or more blood cultures drawn on separate occasions.

Reference: Centers for Disease Control and Prevention National Healthcare Safety Network Manual, Patient Safety Component Protocol, January 2008. Available at: http://www.cdc.gov/nhsn/PDFs/pscManual/4PSC_CLABScurrent.pdf; Accessed December 9, 2009.

Surveillance program

The National Health Safety Network definition of CLABSI was applied (Table 1). The number of patients with one or more central lines of any type was collected daily, at the same time each day, and summed to calculate the number of catheter-days for each period of analysis. Catheter dwell time was defined as the number of days between catheter insertion and onset of CLABSI symptoms. If a patient had a catheter in situ on the day of admission, that date was used as the insertion date. The catheter utilization proportion was calculated by dividing the number of catheter-days by the number of patient-days for each time period.

Surveillance was conducted by 4 certified infection preventionists. They reviewed the medical record of every patient who had a positive blood culture, using a standard data collection form. Each case was then reviewed by the hospital epidemiologist to ensure that it met the case definition. Surveillance of all bloodstream infections has been performed continuously since 1993, with reporting of cases per 1000 patient-days from 1993 to 2005. In 2006, ICU nurses began collecting and reporting device-days to Infection Prevention and Control. After a 6-month pilot phase, during which staff gained experience with device-day monitoring, data collection for the study began. Device-day data collected by ICU nursing staff were compared with data collected daily by the intravenous (IV) catheter management team to confirm the accuracy of data collection.

Baseline period infection control practices

During the baseline period of October 1, 2006, to September 30, 2008, standard infection control practices were as described in the facility's infection control manual, which was available to all nursing staff on the hospital's website at all times. All nursing staff members were required to complete online review training in infection control practices annually and to score of at least 80% on the quiz at the end of the module.

Each CVC insertion site was cleaned with 2% chlorhexidine gluconate (CHG) in alcohol solution, and a transparent dressing was applied weekly or more frequently if wet or soiled. A CHG-impregnated sponge was applied to each catheter insertion site, with a new sponge applied at each dressing change. Training in proper application of the CHG-impregnated sponge was provided by the manufacturer's representative educator (Johnson & Johnson, New Brunswick, NJ). IV tubing for parenteral nutrition solutions was changed daily; tubing for other IV solutions was changed every 72 hours. Polyurethane catheters coated with CHG and silver sulfadiazine were used for subclavian, internal jugular, and femoral sites, unless the patient had a history of hypersensitivity to sulfa drugs or chlorhexidine. Uncoated polyurethane catheters were used for patients with allergy to coating materials. Polyurethane Power peripherally inserted CVCs (PICCs) (Bard, Murray Hill, NJ) comprised 96% of the PICCs used; silicone Groshong catheters (Bard), the remaining 4%.

CVC insertion techniques

A CVC insertion bundle was implemented in April 2006, consisting of (1) hand hygiene and donning of sterile gloves and gown by all persons in the room before beginning the procedure, (2) donning of cap and mask by the physician inserting the catheter, (3) use of a 2% CHG in 70% ethanol scrub for the insertion site, (4) head-to-toe sterile drape of the patient during insertion, (5) time out before performing the procedure, and (6) avoidance of the femoral insertion site. Physicians were trained in the CVC insertion technique by an infection prevention presentation at the beginning of each rotation. Nursing staff were empowered to halt the procedure if a break in sterile technique was observed, and they were tasked with monitoring compliance with the insertion bundle. The PICCs were inserted by 4 trained nurses, following the infection control practices described above.

Intervention period infection control practices

In addition to the baseline infection control practices, an IV team was assembled to provide insertion and site care of PICCs, as well as monitoring of site care and dwell time of all IV catheters throughout the hospital. A line care bundle was developed by the nursing staff and implemented by each nursing unit's IV champion. The bundle consisted of (1) daily inspection of the insertion site; (2) site care if the dressing was wet or soiled, or had not been changed for 7 days; (3) documentation of ongoing need for the catheter; (4) proper application of a CHG-impregnated sponge at the insertion site; (5) performance of hand hygiene before handling the IV system; and (6) application of an alcohol scrub to the infusion hub for 15 seconds before each use.

A 4-hour hands-on training class in techniques for accessing and caring for all IV catheters was mandatory for all nursing staff. This training was followed by a competency evaluation, in which each nurse was required to demonstrate competence in catheter insertion site and hub care. The elements of competency for insertion site care were wearing a mask and sterile gloves for a central line dressing change, scrubbing the site with 2% CHG in alcohol for 30 seconds, and applying the CHG-impregnated sponge properly. The elements of competency for hub care included scrubbing the catheter hub for 15 seconds with an alcohol pad at each access and replacing the hub every 72 hours.

Statistical analyses were performed with GraphPad InStat 3.0 (GraphPad, Software, Inc., San Diego, CA), using Fisher's exact test for comparisons of proportions. The study was approved by the Colorado Multiple Institutional Review Board.

RESULTS

Compliance with the CVC insertion bundle was 94% during the preintervention period and 93% during the intervention period. During the preintervention period of October 1, 2006, to September 30, 2008, there were 11,434 patient-days and 4415 documented catheter-days, for a catheter utilization proportion of 0.39. There were 25 CLABSIs, for an incidence density of 5.7 CLABSIs/1000 catheter-days. The mean, median, and interquartile range of the dwell time of catheters associated with bloodstream infection were 14.5, 12, and 6-24 days, respectively. After implementation of the interventions (October 1, 2008, to September 30, 2009), there were 5937 patient-days and 2825 catheter-days, for a catheter utilization proportion of 0.48 ($P < .0001$). There were 3 CLABSIs, for an incidence density of 1.1 per 1000 catheter-days. The median dwell time of the 3 catheters that were associated with CLABSI during the postintervention period was 7 days (median, 15 days). The relative risk for a CLABSI during the postintervention period compared with the preintervention period was 0.19 (95% confidence interval [CI], 0.06-0.63; $P = .004$). To address the possibility of incomplete catheter-day ascertainment during the baseline period, a calculation was made to estimate the number of catheter-days in the baseline period had the utilization proportion been equal to that in the postintervention period. The postintervention catheter utilization proportion was multiplied by the patient-days during the baseline period, resulting in 5488 estimated catheter-days. When the comparison of incidence densities was repeated, using 5488 catheter-days ($0.48 \times 11{,}434$) as the denominator, the relative risk of CLABSI during the intervention period remained significant at 0.23 (95% CI, 0.07-0.77; $P = .017$).

Details of the CLABSIs are presented in Table 2. No trends in the identity of the pathogen, physician team, or service were noted.

DISCUSSION

Our findings demonstrate that implementation of a CVC postinsertion care bundle was associated with a significant reduction in CLABSIs. When surveillance data indicated an ongoing high incidence density of CLABSI despite excellent compliance with the insertion bundle, we reviewed each case for clues to the underlying reason for the problem. We found no commonalities in physician staff, service, admission diagnosis, or pathogen. We noted that the median dwell time between catheter insertion and onset of infection was 12 days, which led us to suspect that events occurring after insertion might be responsible for the infections.

Recent studies of CLABSI prevention have focused primarily on insertion techniques[2] or have included concurrent changes in techniques of insertion and postinsertion care.[3] Our study of local compliance with recommended postinsertion care techniques revealed opportunities for improvement that could possibly lead to reductions in CLABSI.[4] Our study is the first to demonstrate the impact of improved postinsertion care on the risk of CLABSI in a setting in which compliance with the central line insertion bundle was already high.

The strength of this study is that it focused on postinsertion care of CVCs, while maintaining high compliance with the ongoing central line insertion bundle. This study demonstrates that interventions developed by front-line nursing staff can be a highly effective response to a problem. The study's weakness is that it is a quasi-experimental study conducted at a single medical center.

Attention to sterile technique at the time of CVC insertion is essential to preventing infection, but is not sufficient by itself. The insertion of a CVC results in the ongoing presence of a foreign body traversing the cutaneous barrier; thus, the need for meticulous postinsertion site care to prevent CLABSI is intuitive. Based on previously reported data, we hypothesized that staff education and reinforcement of proper CVC care after insertion, along with careful cleaning of the hub before each access, might reduce the incidence of infection. The elements of postinsertion care, including hand hygiene,[1,5] use of chlorhexidine for site cleansing,[6] CHG-impregnated sponges,[7] and attention to decontamination of access ports with each use,[8] have been

Table 2. Characteristics of bloodstream infection cases

Case	Nursing unit	Diagnosis	Pathogen	Dwell time
Baseline				
1	MICU	Intracranial hemorrhage	*Candida albicans*	14
2	MICU	Acute renal failure	*Staphylococcus aureus*	2
3	MICU	Pneumonia	*Candida glabrata*	47
4	MICU	Subdural hematoma	*Clostridium* spp	13
5	MICU	Pulmonary embolism	*Stapylococcus epidermidis* and *Enterococcus faecium*	2
6	MICU	Effusion	*C albicans*	0
7	MICU	Cardiac arrest	*S aureus*	29
8	MICU	Cardiac arrest	*Enterobacter cloacae*	12
9	SICU	Hip fracture	*Klebsiella pneumoniae*	24
10	SICU	Small bowel obstruction	*Staphylococcus epidermidis*	7
11	SICU	Small bowel obstruction	*Klebsiella pneumoniae*	6
12	SICU	Wound infection	*Candida parasilosis*	3
13	SICU	Enterocutaneous fistula	*Pseudomonas aeruginosa* and *S epidermidis*	18
14	MICU	Laryngeal edema	*Klebsiella oxytoca*	7
15	MICU	Respiratory failure	*E faecium*	30
16	MICU	Renal cancer	*S epidermidis*	7
17	MICU	Respiratory failure	*S aureus*	0
18	SICU	Fever	*C albicans*	1
19	SICU	Fever	*S epidermidis*	7
20	SICU	Acute leukemia	*E cloacae*	32
21	SICU	Lower limb ischemia	*Enterococcus faecalis*	6
22	SICU	Mediastinal mass	*E faecium/S aureus*	25
23	SICU	Rectal cancer	*P aeruginosa*	32
24	SICU	Colon cancer	*Enterobacter aerogenes*	21
25	SICU	Gastric carcinoma	*E faecalis*	18
Postintervention				
1	SICU	Lymphoma	*C glabrata*	7
2	SICU	Colon cancer	*Candida* spp	5
3	MICU	Respiratory failure	*Enterococcus* spp	33

described previously. The present study combined these in a bundle approach, and demonstrated a significant impact on CLABSI incidence density.

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