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Impact of alcohol-impregnated port protectors and needleless neutral pressure connectors on central line-associated bloodstream infections and contamination of blood cultures in an inpatient oncology unit

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Background: A major risk factor for the development of bloodstream infection is the presence of a central venous catheter (CVC), especially in immunocompromised patients. CVC hub contamination is a risk factor for central line-associated bloodstream infection (CLABSI).

Methods: This observational before-after trial in a tertiary care hospital's oncology unit included adult patients with a CVC. During the intervention period, the practice of central line hub care was changed from cleaning with alcohol wipes to using alcohol-impregnated port protectors. To accommodate the protectors, the needleless hubs were changed to a neutral pressure connector. The intervention period (January-July 2010) was compared with a historical control (January-December 2009).

Results: A total of 3,005 central line-days and 1 CLABSI (a rate of 0.3 infections/1,000 central line-days) were documented during the intervention period, compared with 6,851 central line-days and 16 CLABSIs (2.3 infections/1,000 central line-days) during the control period (relative risk, 0.14; 95% confidence interval [CI], 0.02-1.07; $P = .03$). The rate of contaminated blood cultures (CBCs) from central lines was 2.5% (17 of 692) during the control period, but only 0.2% (1 of 470) during the intervention period (relative risk, 0.09; 95% CI, 0.01-0.65; $P = .002$).

Conclusions: The implementation of alcohol-impregnated port protectors and needleless neutral pressure connectors significantly reduced the rates of CLABSIs and CBCs in our oncology patient population.

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In 2002, bloodstream infections accounted for 250,000 infections and more than 30,000 deaths in hospitals across the United States.¹ In 2009, central line-associated bloodstream infections (CLABSIs) accounted for 23,000 infections in inpatient units and 18,000 infections in intensive care units in US hospitals.² A major risk factor for the development of a bloodstream infection is the presence of a central venous catheters (CVC).³ This is especially true in critically ill and immunocompromised patients with malignant disorders.⁴

Multiple comprehensive guidelines on the prevention of CLABSIs have been published.⁵⁻⁸ The Joint Commission made prevention of bloodstream infections a 2010 National Patient Safety Goal to emphasize the importance to health care organizations.⁹ Improper CVC hub care can lead to CLABSIs as well as to contaminated blood cultures (CBCs). Strategies to optimize hub care, including proper disinfection of the hubs and good hand hygiene, are essential to decreasing the rates of CLABSIs and CBCs. The current recommendation for disinfecting hubs includes the use of 70% isopropyl alcohol, chlorhexidine, or a combination of the two.^{6,10}

The National Healthcare Safety Network (NHSN) report issued in December 2009 set national benchmarks for institutions regarding CLABSIs in bone marrow transplant and hematology/oncology units. More than 50 bone marrow transplant and hematology/oncology units contributed to this pooled dataset. The data are categorized by type of CVC, either permanent lines (tunneled

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catheters and implanted ports) or temporary lines (nontunneled catheters). For permanent lines, the median infection rates were 1.8 CLABSIs/1,000 central line-days for the bone marrow transplant units and 0.9 CLABSIs/1,000 central line-days for the hematology/oncology units; corresponding rates for temporary lines were 1.3 and 1.4 CLABSIs/1,000 central line-days.¹¹ Historical rates of CLABSIs in our institution were substantially higher than those reported in the 2009 NHSN report. An internal review of CLABSIs among our hematologic and bone marrow transplant recipients identified colonization of the catheter hub from the skin as a major contributor to CLABSIs, given that infections occurred more than 7 days after CVC insertion. The average time to infection was 14 days after insertion.

Alcohol-impregnated port protectors, a novel device used for the prevention of CLABSIs and CBCs, have shown efficacy in laboratory studies, but have not yet been studied extensively in the clinical setting. They help prevent CLABSIs and CBCs by optimizing hub disinfection through thorough cleaning of the catheter hub. The port protectors are luer-lock style caps, which provide scrubbing and cleaning as the protectors are twisted onto and off of the catheter hubs. A new protector is used each time the port is accessed. There is no maximum time limit for the protector to remain in place. Our quality improvement project involved switching our traditional catheter hub care using alcohol wipes to care using 70% isopropyl alcohol-impregnated port protectors (CUROS; Ivera Medical, San Diego, CA) and needleless neutral-pressure connectors (MicroCLAVE; ICU Medical, San Clemente, CA) on the adult hematology and oncology floors. During this change, alcohol wipes could be used in addition to port protectors at the individual nurse's discretion. Before this intervention, all peripherally inserted central catheters (PICCs) had neutral-pressure connectors.

The objective of this study was to assess the effect of optimizing hub disinfection using this quality improvement intervention by measuring the rate of CLABSIs and CBCs in our adult oncologic patient population.

METHODS

This quality improvement measure was a single-center analysis in the hematology/oncology unit at West Virginia University Hospitals. The study was approved by the Institutional Review Board.

Before implementation, we conducted a retrospective review of the hospital's electronic databases from January 1 through December 31, 2009, for CLABSIs and from July 1 through December 31, 2009, for CBCs. Culture results obtained within 48 hours of admission were excluded, to focus on hospital-acquired infections. To evaluate CLABSI and CBC rates, we collected the following data: number of patients with CVCs located on the hematology/oncology unit, number of patient-days, number of CVC-days (ie, number per patient per day), positive blood culture results, and positive blood cultures obtained through CVCs. This same data was collected for the 6-month period after implementation on January 11, 2010. The CLABSI incidence was reported per 1,000 central line-days to standardize the rates with varying numbers of patients and lines during the different time periods.

Each incidence of bacteremia was reviewed by the hospital's Infection Control Department and the Epidemiologist to determine whether it met the definition of a CLABSI. All CLABSIs were defined using NHSN criteria: (1) 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, or (2) at least one of fever (>38°C), chills, or hypotension, and the signs and symptoms and positive laboratory results are not related to an infection at another

Table 1
Patient characteristics

	Preintervention	Intervention	P value*
Patients with CVC, n	836	436	
Male sex, % (n)	48.9 (409)	49.0 (214)	.90
Age, years, mean (range)	56.3 (20–91)	56.4 (19–92)	.90
Oncologic disease, % (n)			
Acute leukemia	24.5 (205)	23.4 (102)	.70
Chronic leukemia	2.4 (20)	2.5 (11)	.89
Lymphoma	17.7 (148)	14.7 (64)	.20
Myeloma	5.1 (43)	5.9 (26)	.60
Other	5.0 (42)	6.2 (27)	.46
Solid tumor	38.9 (325)	38.1 (166)	.80
No oncologic disease	6.3 (53)	9.2 (40)	.08
Charlson Comorbidity Index score, mean (range)	4.1 (0–13)	4.3 (0–14)	.23
Receipt of systemic antibiotics, % (n)	75.8 (634)	76.6 (334)	.81

*All values statistically nonsignificant.

site, and the common skin contaminant (ie, diphtheroids [*Corynebacterium* spp], *Bacillus* [not *B anthracis*] spp, *Propionibacterium* spp, coagulase-negative staphylococci [including *S epidermidis*], *Streptococcus viridans* group, *Aerococcus* spp, *Micrococcus* spp) is cultured from 2 or more blood cultures drawn on separate occasions from any site.¹² Along with meeting either of the foregoing criteria, a patient also had to have a CVC (eg, PICC, tunneled catheter, implanted port) at the time of or within 48 hours before the culture was obtained. A CBC was defined as any positive blood culture drawn from any CVC that contained one of the aforementioned organisms, did not meet the criteria for CLABSI, and was drawn after 24 hours of admission, with no previous history of a positive culture of that same organism.

All PICCs were inserted at the bedside by a nurse on the PICC insertion team. All tunneled venous catheters and ports were uniformly inserted in the operating room by an experienced surgeon or interventional radiologist under sterile conditions. Other temporary CVCs could have been placed by a physician at either the bedside or in the operating room. Line insertion technique, antibiotic prophylaxis for bone marrow transplantation, and culturing protocols remained unchanged throughout both study periods. Line insertion technique followed best practices, including appropriate handwashing, full body drape, full sterile garb, chlorhexidine skin preparation, and maintenance of the sterile field. Blood cultures were drawn from either a peripheral site and from the central line or 2 draws from different lumens in the same line during both time periods. Antibiotic-impregnated catheters were not used. Compliance with the intervention was assessed by weekly point prevalence observations and defined as the percentage of patients with catheter protectors. All other infection control interventions were similar in the 2 groups.

The primary outcome of this study was the reduction of CLABSIs after the implementation of a quality improvement measure. The secondary outcome was the reduction of CBCs. Changes in CLABSI and CBC rates were analyzed by Fisher's exact test, using GraphPad (GraphPad Software, San Diego, CA), with 2-tailed *P* values and descriptive statistics.

RESULTS

During the year before implementation, 472 patients with CVCs accounted for a total of 911 hospital admissions and 6,851 central line-days. Sixteen CLABSIs were documented during this pre-intervention period. The 6-month intervention period involved 282 patients, who accounted for a total of 479 hospital admissions and 3,005 central line-days. There were no significant statistical

Table 2
Central line characteristics

Central line type	Preintervention, % (n)	Intervention, % (n)	P value*
PICC	47.8 (400)	50.9 (222)	.30
Implanted port	30.9 (259)	29.4 (128)	.59
Subclavian	11.0 (92)	10.5 (46)	.80
Internal jugular	0.95 (6)	1.8 (8)	.13
Femoral	2.3 (19)	2.5 (11)	.90
Multiple	7.2 (60)	4.8 (21)	.13

*All statistically nonsignificant.

Table 3
Distribution of CLABSI organisms

Organism	Preintervention	Intervention
Coagulase-negative staphylococci	4	
MRSA	2	1
<i>Escherichia coli</i>	2	
<i>Streptococcus viridans</i>	1	
<i>Klebsiella pneumoniae</i>	1	
Mixed	6	
Total	16	1

differences in baseline characteristics between the 2 groups (Table 1). The 2 groups also did not differ significantly in terms of the types of central lines placed (Table 2). One CLABSI was documented during the intervention period.

The rate of CLABSIs decreased from 2.3/1,000 central line-days in the preintervention period to 0.3/1,000 central line-days in the intervention period (relative risk, 0.14; 95% CI, 0.02–1.07; $P = .03$). The rate of CLABSI per 100 patient admissions also decreased between these 2 periods, from 2.1 to 0.2 ($P = .01$). The corresponding rate of CBCs decreased from 2.5% (17 of 692) to 0.2% (1 of 470) (relative risk, 0.09; 95% CI, 0.01–0.65; $P = .002$).

Coagulase-negative staphylococci were the most common organisms cultured during the preintervention period, accounting for 25% of CLABSIs and 88% of CBCs. No coagulase-negative staphylococci were found during the intervention period, however. A wide variety of organisms were responsible for the CLABSIs and CBCs (Tables 3 and 4). Six mixed CLABSIs were recorded: (1) *Enterobacter cloacae* and *Candida glabrata*; (2) coagulase-negative staphylococci and *Escherichia coli*; (3) *Corynebacterium* spp and *Streptococcus viridans*; (4) *Enterococcus faecium*, *Candida krusei*, and coagulase-negative staphylococci; (5) *Klebsiella oxytoca*, methicillin-resistant *Staphylococcus aureus* (MRSA), and *Enterococcus faecalis*; and (6) *Stomatococcus* spp and coagulase-negative staphylococci.

Before implementation, the average and median indwelling time of catheters associated with CLABSIs was 14 days. The majority of the infected catheters (14 of 15) were in place for at least 10 days. One CLABSI was related to 2 lines, one in place for 4 days and the other in place for 16 days. The only CLABSI recorded during the intervention period was associated with a catheter in place for 12 days. The rate of adherence to the intervention was 85.2% (228 of 269).

DISCUSSION

Health care–associated infections are now more commonly caused by highly resistant organisms, such as MRSA, vancomycin-resistant enterococci, extended-spectrum β -lactamase–producing Enterobacteriaceae and panresistant *Acinetobacter* species. These resistant organisms can be challenging to treat and are associated with increased mortality and morbidity.^{13–15} The paradigm for dealing with health care–associated infections needs to shift from treatment to prevention. Strategies to prevent CLABSIs can be

Table 4
Distribution of contaminated blood culture organisms

Organism	Preintervention	Intervention
Coagulase-negative staphylococci	15	
<i>Corynebacterium</i> spp	1	1
<i>Micrococcus</i> spp	1	
Total	17	1

categorized into 3 areas of practice: before central line insertion, at the time of insertion, and after insertion.

Our review of the CLABSIs occurring in the preintervention period suggested suboptimal catheter hub disinfection during that period. Our data showed that the majority of CLABSIs were associated with lines in place for at least 10 days, suggesting suboptimal maintenance as opposed to insertion as the cause.¹⁶ The primary goals of our intervention were to decrease CLABSIs and CBCs by improving the maintenance care (after insertion) of central lines. Standard recommendations after line insertion include disinfecting the catheter hub, needleless connector, and injection port every time before the catheter is accessed. Current recommendations do not specify a duration of hub disinfection; previous studies have shown that 5 seconds is insufficient, and that 15 seconds may be adequate.^{17,18} Unfortunately, with no consensus on this, current practice varies from 15 to 60 seconds.

In this study, the use of port protectors and needleless neutral-pressure connectors was associated with a statistically significant reduction in CLABSIs and CBCs. We believe that our intervention was successful due in part to the type of organisms (skin flora) causing most of the infections and contaminated cultures. A decrease in microbial colonization of the skin and hub results in less microbial burden and consequently fewer false-positive cultures. Reducing false-positives in return decreases the costs related to unnecessary diagnostic tests, line removal, antibiotic use, and delays in discharge.^{19,20} The Centers for Disease Control and Prevention's guidelines for the prevention of intravascular catheter–related infections cites an abstract from Kluger and Maki⁵ from the 1999 Interscience Conference on Antimicrobial Agents and Chemotherapy reporting a 12%–25% mortality rate associated with these infections. An annualized reduction of 14 CLABSIs would prevent an estimated 1–3 fatalities per year in our population.

Because the use of port protectors and neutral connectors was implemented simultaneously, determining which of the 2 interventions had the most impact is difficult. Needleless closed systems have been reported to reduce catheter tip colonization, and we previously used the connectors on all PICCs.²¹ To explore this issue, we performed an ad hoc analysis of the PICCs, because the only intervention in this group was the use of port protectors. The rate of CLABSI cases per 1,000 PICC-days decreased from 2.3 to 0 (relative risk, 0.13; 95% CI, 0.01 to 2.2; $P = .02$). This statistically significant decrease in the number of CLABSIs associated with PICCs suggests that the use of port protectors decreased the rate of CLABSIs independent of the neutral connectors. This finding does not suggest that the use of neutral connectors does not contribute to the decreased rate of infection, however. The rate of CBCs associated with PICCs decreased from 2.5% (10 of 400) in the preintervention period to 0.5% (1 of 222) in the intervention period (relative risk, 0.18; 95% CI, 0.02–1.37; $P = .10$). The rate of CBCs was not sufficiently powered to show a statistical difference between the 2 groups for PICCs, but did demonstrate a decrease. A future study that is appropriately powered to identify a difference in PICC-associated CBCs would be helpful to further investigate this question.

Limitations of this study included its unblinded before–after observational design, and the fact that the use of alcohol wipes for

disinfection could have increased due to an increase in staff awareness with the ongoing intervention.

In conclusion, in our oncology patient population with possible suboptimal catheter maintenance demonstrated by CLABSIs and CBCs associated with skin flora, the use of port protectors and needleless neutral-pressure connectors demonstrated a beneficial effect on patient care outcomes. Implementation was relatively simple, and education of the nursing staff took less than a week. The use of these devices became the standard of practice in the unit and was associated with a high rate of compliance. Larger studies should be performed in oncology patients and other high-risk populations to further assess the effectiveness of this approach.

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