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Reduction in Central Line–Associated Bloodstream Infections Correlated With the Introduction of a Novel Silver-Plated Dressing for Central Venous Catheters and Maintained for 6 Years

Rachel Karlnoski, PhD[1], Elia Charbel Abboud, MD[1], Peggy Thompson, BSN, CIC, FAPIC[2], Asa Z. Oxner, MD[3], John T. Sinnott, MD, FACP[4], and Jorge E. Marcet, MD, FACS, FASCRS[1]

Abstract

Objective: To assess a novel silver-plated dressing (SD) for central venous catheters in comparison to chlorhexidine gluconate–impregnated sponge (CHGIS) dressings in preventing central line–associated bloodstream infections (CLABSIs) in adult intensive care unit (ICU) patients. **Design:** Retrospective cohort study. **Setting:** Tampa General Hospital, an academic medical tertiary care center. **Patients:** All adult ICU patients of an academic medical tertiary care center from January 2009 to December 2010. **Measurements and Main Results:** A total of 3189 patient records were studied from 7 different ICUs during the 2-year period. Patients received either CHGIS dressings (January 2009-December 2009) or SDs (January 2010-December 2010). Primary outcomes measured were CLABSI rates per 1000 catheter days and ICU length of stay. There were 30 696 catheter days with CHGIS dressings and 31 319 catheter days with SDs. There was a statistically significant decrease in the rate of CLABSI per 1000 catheter days in the SD group, from 2.38 to 1.28 ($P = .001$), with an absolute risk reduction of 1.1. There was a significantly lower incidence in the rate of CLABSI per 1000 catheter days in the SD group (incidence rate ratio [IRR] = 0.54, 95% confidence interval [CI]: 0.36-0.80). The relative risk of CLABSI in the SD group was 0.502 (95% CI: 0.340-0.730; $P < .001$). If SDs are used on all catheters, the decreased rate of CLABSIs observed would calculate to a cost savings of US$4070 to US$39 600 per 1000 catheter days. After successful implementation of the SD, we observed significant reductions in CLABSI rates and a sustained reduction in the subsequent 6 years. **Conclusion:** Use of SDs is associated with a significant decrease in CLABSI rates in adult ICU patients compared to CHGIS dressings, with an estimated cost savings of US$4070 to US$39 600 per 1000 catheter days.

Keywords

silver-plated dressing, central venous catheter, central line–associated bloodstream infection, intensive care unit, reduced infection rate, chlorhexidine gluconate–impregnated sponge dressing

Introduction

Patients admitted to intensive care units (ICUs) often require the placement of central venous catheters (CVCs). In 2013, 48% of ICU patients had CVCs, accounting for approximately 9.2 million CVC days, and an estimated 30 100 central line–associated bloodstream infections (CLABSIs).[1-4] Patient mortality rates associated with CLABSIs range from 12% to 25%,[4] and the cost of CLABSIs per episode of care ranges from US$3700 to US$36 000.[5] The average infection rate for adult ICUs reported in 2013 by the National Healthcare Safety Network (NHSN) ranged from 0.8 to 2.9 per 1000 catheter days.[1] Central line–associated bloodstream infection prevention is clearly of prime importance.

Several strategies have been studied and developed in an attempt to prevent CLABSIs, varying from the more expensive

[1] Department of Surgery, University of South Florida, Morsani College of Medicine, Tampa, FL, USA
[2] Department of Infection Prevention, Tampa General Hospital, Tampa, FL, USA
[3] Department of Internal Medicine, Beth Israel Deaconess Medical Center, Boston, MA, USA
[4] Department of Internal Medicine, University of South Florida, Morsani College of Medicine, Tampa, FL, USA

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Corresponding Author:
Rachel Karlnoski, Division of Colon and Rectal Surgery, Department of Surgery, University of South Florida, 5 Tampa General Circle, Suite 740, Tampa, FL 33606, USA.
Email: rkarlnos@health.usf.edu

technologic innovations, such as coated catheters, to lower-cost interventions, including aseptic insertion technique and reduced catheter time.[6] The Centers for Disease Control and Prevention (CDC) reported a 50% reduction in ICU CLABSI rates in the United States from 2008 to 2014.[3] Currently, it is thought that most CLABSIs are preventable.[7]

Use of chlorhexidine gluconate–impregnated sponge (CHGIS) dressings has been associated with reduced rates of CLABSIs.[8,9] A multicenter randomized controlled trial found that CHGIS dressings significantly decreased the rates of catheter colonization and CLABSIs.[10] Another trial found that use of these dressings in hematological–oncological patients reduced the rate of CLABSIs by 46%.[11]

Silver has a broad spectrum of antimicrobial activity.[12] The extensive coverage that silver provides against bacteria, fungi, and viruses, including the notorious nosocomial pathogens methicillin-resistant *Staphylococcus aureus* and vancomycin-resistant enterococci,[13] makes it a valuable adjunct in the prevention and treatment of infection. Silver has both bactericidal effects via oxidation of the cell membrane and bacteriostatic effects by inhibiting bacterial replication through damage to DNA.[14-17] Fortunately, toxicity of silver to human cells is considerably less than to bacteria.[18] Unlike antibiotics, resistance to silver is very rare; instead of targeting a specific cellular process, silver ions directly interact with proteins and other organic molecules and disrupt electrolyte balances. Silver's affinity to multiple microbial molecules and structures further decreases the risks of resistance.[16,17] A variety of silver dressings are commercially available today. Silver impregnated dressings have been shown to be effective in preventing surgical site infections even in the contaminated context of colorectal surgery, where infection rates reach 30%.[13]

There are few studies evaluating non-CHGIS dressings for CVCs. The objective of this observational study was to describe the outcomes of Silverlon Lifesaver Ag (Cura Surgical, LLC; Geneva, IL) a novel silver-plated dressing (SD), in comparison to CHGIS dressings in preventing CLABSIs in adult ICU patients.

Materials and Methods

This study was approved by the institutional review board of University of South Florida (IRB#Pro00015734) and was carried out in an academic medical tertiary care center (Tampa General Hospital, Tampa, FL). Our hospital's Department of Infection Prevention (DIP) collects prospective data on CLABSIs in ICUs for ongoing quality improvement. In each ICU, a staff member is designated to take daily record of each patient's number of central line days. These data are forwarded to the DIP office for entry into a spreadsheet to facilitate calculation of CLABSI rates per central line days, which allows for comparison of rates with ICU-specific NHSN data. For this study, the DIP database was queried to reveal data of 3189 patients with central line days who had an ICU stay between January 2009 and December 2010 from 7 different ICUs: medical, coronary care, neurological, burn, surgical trauma, cardiothoracic, and vascular. The center's billing records were queried to identify the medical record numbers of those 3189 patients. Medical records were retrospectively reviewed to capture demographic information. Between January and December 2009, all patients received a CHGIS dressing on their CVC as per hospital policy. From January to December 2010, all patients received the novel SD on their CVC as per hospital policy. After the study ended in December 2010, our hospital policy continued to enforce the use of the novel SD on all CVCs.

Catheter site dressing regimens were the same in all patients within each group. Other than implementation of the SD, the center's ICU CVC protocols remained the same in 2010 compared to 2009 and continue to remain the same. Per hospital policy, the antiseptic used to prepare the skin prior to CVC insertion was 2% chlorhexidine in 70% isopropyl alcohol. In patients who could not tolerate chlorhexidine, a 1% tincture of iodine was used. Following manufacturer's instructions, CHGIS dressings were applied at the insertion site with the blue side up, and SDs were moistened with sterile water or saline and applied silver side down. All CVC dressings were covered with a transparent adhesive film. If there was bleeding from the puncture site, gauze was placed over the antimicrobial dressing. The gauze was removed at 24 hours, and a new antimicrobial patch (CHGIS or SD) was placed and covered with a transparent adhesive film. The transparent films and antimicrobial patches were changed if they became compromised or when inspection of the site was necessary. Dressings were otherwise replaced every 7 days. In order to maintain consistency with insertion practices, all necessary materials were combined in a bundled kit and placed on a designated cart for line insertion. In order to measure compliance, completion of an insertion checklist was required by all clinicians and monitored regularly by the DIP. These quality improvement measures were in place prior to the study period.

Central line–associated bloodstream infection rates are compared with the CDC's NHSN data in analogous ICUs for benchmarking. The DIP is supported by an electronic surveillance system that allows review of all laboratory data on ICU patients. These results are reviewed daily and specific criteria are used to define device-associated infections. A CLABSI in the study period was defined as meeting at least 1 of the following 2 CDC/NHSN-defined criteria[19]:

1. Patient has a recognized pathogen (eg, *S aureus*, *Enterococcus* subspecies, *Escherichia coli*, *Pseudomonas* subspecies, *Klebsiella* subspecies, *Candida* subspecies, and others), but *not* a common skin contaminant, cultured from 1 or more blood cultures, *and* the organism cultured from the patient's blood is not related to an infection at another site.
2. Patient has at least 1 of fever (>38°C), chills, or hypotension; a common skin contaminant (diphtheroids [*Corynebacterium* subspecies], *Bacillus* subspecies [not *Banthracis*], *Propionibacterium* subspecies, coagulase-negative staphylococci [including *Staphylococcus*

Table 1. Demographic and Clinical Variables.[a]

Variables	CHGIS (n = 1524)	SD (n = 1665)	*P* Value
Age, mean (standard deviation), years	58.1 (16.8)	59.2 (16.5)	.07
Gender			.76
Male	832 (54.5)	918 (55.1)	
Female	692 (45.5)	747 (44.9)	
Days in ICU (standard deviation)	13.1 (29.5)	12.6 (15.8)	.85
ICU type			<.001
Medical	143 (9.4)	232 (13.9)	
Coronary care	314 (20.6)	343 (20.6)	
Neurological	362 (23.8)	324 (19.5)	
Burn	130 (8.5)	117 (7.1)	
Surgical trauma	248 (16.2)	277 (16.6)	
Cardiothoracic	219 (14.4)	275 (16.5)	
Vascular	108 (7.1)	97 (5.8)	

Abbreviations: CHGIS, chlorhexidine gluconate–impregnated sponge; ICU, intensive care unit; SD, silver-plated dressing.
[a]Data are number (%), unless otherwise indicated.

> *epidermidis*], viridans group streptococci, *Aerococcus* subspecies, and *Micrococcus* subspecies) is cultured from 2 or more blood cultures drawn on separate occasions within 2 days of each other; *and* signs and symptoms and positive laboratory results are *not* related to an infection at another site.

Bloodstream infections that developed within 48 hours of discharge from the ICU were considered CLABSIs. There was no minimum time period that the CVC had to be in place in order for the bloodstream infection to be considered central line associated.

The primary outcomes measured were CLABSI rates per 1000 catheter days and length of stay in the ICU. Statistical analysis was performed using the χ^2 test for categorical data and Student *t* test for continuous data. A *P* value of less than .05 was considered significant.

Published estimates of attributable cost per CLABSI for studies performed in the United States (US$3700-US$36 000) were used to calculate cost savings.[5] We followed the Strengthening the Reporting of Observational Studies in Epidemiology guidelines for reporting our results.[20]

Results

There were 1524 adult ICU patients between January and December 2009 (the CHGIS dressing period), with a total of 30 696 catheter days. Between January and December 2010 (the SD time frame), there were 1665 adult patients in the center's ICUs, totaling 31 319 catheter days. Age and gender demographics were similar between the 2 groups (Table 1). The length of stay in the ICU was not significantly different (CHGIS: 13.1 days vs SD: 12.6 days; $P = .85$). However, the distribution of patients across ICUs was not homogenous ($P < .001$).

There were 73 infections in the CHGIS group during a total of 30 696 catheter days, and 40 infections in the SD group during 31 319 catheter days. These results correspond to a statistically significant decrease in CLABSI in the SD group: 2.38 infections per 1000 catheter days versus 1.28 infections per 1000 catheter days ($P = .001$), with an absolute risk reduction of 1.1 per 1000 catheter days. There was a significantly lower incidence in the rate of CLABSI per 1000 catheter days in the SD group, with an IRR of 0.54 (95% confidence interval [CI]: 0.36-0.80). The relative risk of CLABSI in the SD group was 0.502 (95% CI: 0.340-0.730; $P < .001$).We have sustained low rates of CLABSI in our ICU in the subsequent period of time since the study period ended, which is tracked as part of our ICU quality improvement process (Figure 1).

Using the estimates of attributable cost per CLABSI (US$3700 to US$36 000),[5] the absolute risk reduction of 1.1 per 1000 catheter days observed for the rate of CLABSI in the SD group translates to an estimated cost savings of US$4070 to US$39 600 per 1000 catheter days. For our center, there were 33 fewer CLABSIs in the 12-month period when SDs were implemented (despite an increase in the total number of catheter days), and this translates to a cost savings estimate of US$122 100 to US$1 188 000 over the 1-year study period.

Discussion

The antimicrobial and wound healing properties of silver have been exploited for centuries. Drinking from silver vessels was practiced as early as 4000 BC, and the Roman civilization documented silver nitrate as a therapeutic agent in their medical books.[21] Silver is used in various forms in medicine today. Examples of commonly used silver products include silver salts, such as silver sulfadiazine topical creams, and silver sustained release products, such as the SD used in this study.

Hospital-acquired infections are a significant cause of patient morbidity and mortality, prolonged hospital stay, and increased costs. A number of clinical trials have shown silver-impregnated dressings to reduce these iatrogenic infection rates and improve wound healing.[12-13,22-31] For this reason, silver dressings are commonly used in the treatment of a wide variety of wounds today, including burns, traumatic lacerations, ulcers, and surgical sites. The study presented here is the first to demonstrate the use of silver nylon dressings for the purpose of reducing CLABSIs. In this cohort study, SDs were found to significantly decrease CLABSIs in adult ICU patients compared to patients using CHGIS dressings. This reduction in CLABSI rates was found to be associated with significant cost savings.

The results of this study in reduction of CLABSIs and expected cost savings are very encouraging. This study does have limitations, however, which must be taken into consideration. For example, we did not collect data on significant risk factors for CLABSI, such as preexisting bloodstream infections, fever within 24 hours of catheter placement, concurrent indwelling catheters, immunodeficiency, and dialysis. We also did not account for patients with preexisting CVCs prior to ICU

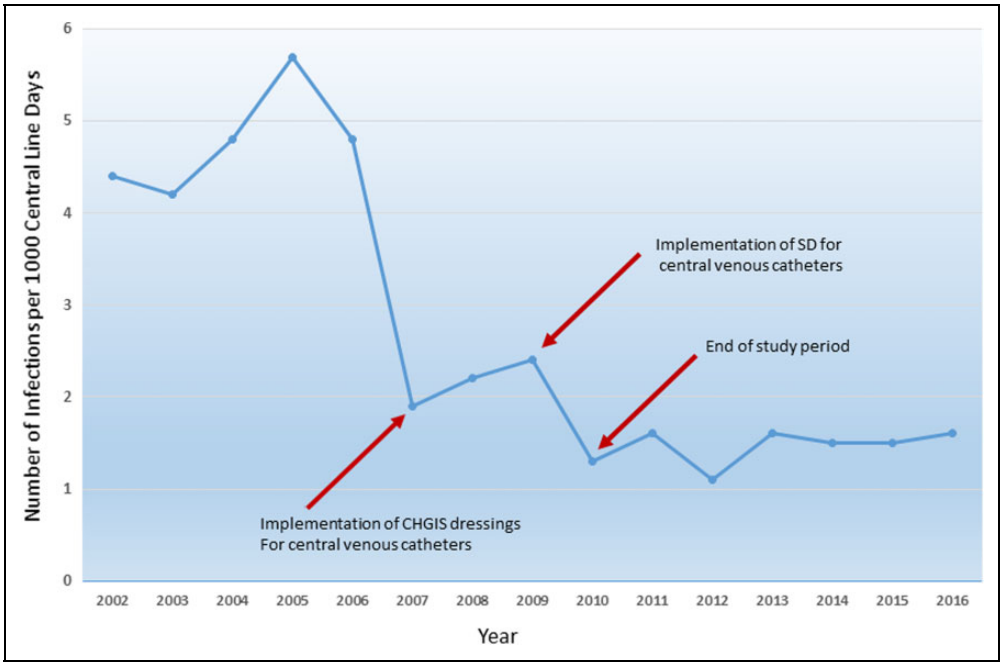

Figure 1. Central line–associated bloodstream infection (CLABSI) rates adult intensive care units (ICUs) combined.

transfer or the location of the line placement. This leads to the inability to match the groups. Also, it was assumed that the overall population of the hospital did not change significantly during the study time period and thus the comorbidities and indications for CVCs were comparable in the 2 groups across time. Cost data were not collected individually for the patients in this study, and the calculated cost savings are estimates, using values obtained from published reports in the medical literature.[5] Because this study was a before-and-after design, it is limited by confounding factors related to changes in environmental variables, such as changes in clinical management or quality improvement. There is a possibility that increased awareness of the problem of CLABSI could have theoretically led to improved medical practice (Hawthorne effect). However, a bundle approach and clinical protocol have been implemented prior to the initial year of the study, with the type of CVC dressing being the only difference between the groups. A well-designed prospective randomized controlled trial will ensure homogenous stratification of patients across the different ICUs and will control for confounding variables between the groups. A prospective, controlled trial will also allow for the collection of more accurate data for cost.

Much success has been achieved over the past decade in reducing the rate of CLABSIs in ICUs.[4] However, it should be noted that CVCs are also used in a range of other health-care settings and increasingly in the outpatient setting and long-term care facilities.[7] As well, peripherally inserted central catheter (PICC) lines are frequently used for long-term intravenous access and are often replacing inpatient CVCs.[32] This leads to additional questions which deserve to be studied: Will SDs be as effective in reducing CLABSIs and associated cost in non-ICU patients and in outpatient settings? How effective will SDs be in reducing infection and related cost in PICC lines and in pediatric populations?

Despite the reduction in central line infections owing to the improvement with insertion and maintenance techniques in recent years, CLABSIs still occur today.[33] Continued success in prevention of these infections requires strict adherence to current prevention recommendations and the development and implementation of novel prevention strategies in daily practice.[4] We believe that the positive results we have obtained in this study for SDs reducing CLABSIs deserve serious consideration for the routine use of the SD in CVC care protocols in adult ICUs.

Conclusion

This study demonstrates that the use of SD for CVCs is associated with a significant decrease in CLABSIs in adult ICU patients compared to patients receiving the CHGIS dressing. The observed reduction in CLABSIs calculates to an estimated cost savings of US$122 100 to US$1 188 000 per 1000 catheter days. This leads to an estimated cost saving of over a million dollars for our hospital center during the 1-year study period.

Authors' Note

Preliminary data for this study were presented as a poster at the 49th Annual Meeting of the Infectious Diseases Society of America (IDSA)—Boston, Massachusetts—October 20-23, 2011. The work was performed at Tampa General Hospital, University of South Florida.

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Declaration of Conflicting Interests

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