

Effectiveness of a care bundle to reduce central line-associated bloodstream infections

The central line-associated bloodstream infections rate ... decreased from 2.2 in the pre-intervention period to 0.5 in the post-intervention period

Central line-associated bloodstream infections (CLABSIs) are an important source of morbidity, mortality and cost.¹ About 4000 CLABSIs occur in Australian intensive care units (ICUs) each year, with an estimated nationwide cost of \$36.26 million and a mortality rate of 4%–20%.^{2,3} The importance placed on CLABSI and its prevention has prompted standardised monitoring for quality assurance and innovation of preventive strategies.^{1,4,5} Care bundles focused on improving line insertion procedure have proven successful overseas.^{1,6} Local implementation of a similar care bundle to that used overseas across New South Wales proved successful, and prompted the Australian and New Zealand Intensive Care Society CLABSI Prevention Project.^{7,8} Despite these interventions, CLABSI rates range from 0.9 to 3.6 per 1000 central line days.^{6,7,9–20}

The Victorian Healthcare Associated Infection Surveillance System (VICNISS) collects standardised ICU CLABSI rates for the state of Victoria.²¹ Since 2006, the University Hospital Geelong (UHG) ICU has reported CLABSI rates to VICNISS.

An elevated reported CLABSI rate at UHG in 2007 and 2008 (3.8 and 3.6, respectively, compared with the state average of 2.7 per 1000 central line days)²² prompted development and introduction of a CLABSI prevention care bundle. Our care bundle used an effective line insertion procedure identified from previous studies,^{1,6,7} but also incorporated a novel maintenance procedure. In this article, we report the effectiveness of this care bundle in a tertiary ICU in Victoria.

Methods

We undertook a before-and-after study, retrospectively accessing the pre-intervention data, at an adult, tertiary, 19-bed ICU that admits medical, surgical and cardiac surgical patients.

Abstract

Objective: To determine the effectiveness of a care bundle, with a novel line maintenance procedure, in reducing the rate of central line-associated bloodstream infection (CLABSI) in the intensive care unit (ICU).

Design, participants and setting: Before-and-after study using CLABSI data reported to the Victorian Healthcare Associated Infection Surveillance System (VICNISS), in adult patients admitted to a tertiary adult ICU in regional Victoria between 1 July 2006 and 30 June 2014. VICNISS-reported CLABSI cases were reviewed for verification. An intervention was implemented in 2009.

Intervention: The care bundle introduced in 2009 included a previously established line insertion procedure and a novel line maintenance procedure comprising Biopatch, daily 2% chlorhexidine body wash, daily ICU central line review, and liaison nurse follow-up of central lines.

Main outcome measures: CLABSI rate (cases per 1000 central line days).

Results: The average CLABSI rate fell from 2.2/1000 central line days (peak of 5.2/1000 central line days in quarter 4, 2008) during the pre-intervention period to 0.5/1000 central line days (0/1000 central line days from July 2012 to July 2014) during the post-intervention period.

Conclusion: Our study suggests that this care bundle, using a novel maintenance procedure, can effectively reduce the CLABSI rate and maintain it at zero out to 2 years.

Ethics approval was obtained from the Barwon Health Research Review Committee. This project was performed as part of the authors' usual roles and no funding or subsidy was received. All of us had full access to the study data.

Intervention

The care bundle was based on the Australian and New Zealand Intensive Care Society CLABSI prevention project,⁸ comprehensive literature review and collaboration between UHG ICU, UHG Infection Control Services and other key stakeholders. The final care bundle (Appendix 1) included standard line insertion procedure consistent with that described previously,^{6,7} bedside audit by an observer with stopping rules, and a novel line maintenance procedure that included placement of a Biopatch (Johnson and Johnson), sterile line access, daily 2% chlorhexidine body wash, daily central venous catheter (CVC) review with early line removal, and liaison nurse follow-up of all CVCs present at discharge.

Study procedure

All adult patients admitted to UHG ICU between 1 July 2006 and 30 June 2014 were captured in this study. The care bundle was introduced in 2009, dividing patients into a pre-intervention period (1 July 2006 to 31 December 2009) and a post-intervention period (1 January 2010 to 30 June 2014). Case identification of CLABSI was based on the VICNISS dataset and review of blood cultures. All VICNISS-reported CLABSI cases were reviewed by one of us (DE) to confirm that they fulfilled the current VICNISS definition (Appendix 2). This definition is consistent with the internationally accepted O'Grady definition that has been previously applied.^{7,23}

All confirmed CLABSIs were included in the analysis, irrespective of whether line insertion occurred in the ICU. Cohort demographic, basic clinical and microbiological data were collected from the hospital electronic database. Patient medical records of all VICNISS-reported CLABSI cases were reviewed to confirm CLABSI definition and collect additional clinical information. Finally, all positive

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doi:10.5694/mja14.01644

1 Patient population characteristics, and ICU interventions and outcomes, for the pre- and post-intervention periods

	Pre-intervention	Post-intervention	<i>P</i>
No.	4701	6273	
Mean age in years (SD)	64.2 (16.6)	59.4 (21.2)	< 0.001
Male, no. (%)	2870 (61%)	3857 (61%)	0.64
Median APACHE III score (IQR)	48 (37–64)	50 (38–67)	0.001
Comorbidity, no. (%)			
Respiratory	233 (5%)	204 (3%)	< 0.001
Cardiovascular	453 (10%)	176 (3%)	< 0.001
Hepatic	42 (1%)	117 (2%)	< 0.001
Renal	103 (2%)	134 (2%)	0.84
Immunosuppression	271 (6%)	544 (9%)	< 0.001
Cancer	231 (5%)	301 (5%)	0.78
Category, no. (%)			
Medical	1863 (40%)	3250 (52%)	< 0.001
Surgical	1071 (23%)	1027 (16%)	< 0.001
Cardiac surgical	1767 (38%)	1996 (32%)	< 0.001
ICU admission source, no. (%)			
Operating theatre	2752 (59%)	2988 (48%)	< 0.001
Emergency department	910 (19%)	1565 (25%)	< 0.001
Ward	801 (17%)	1280 (20%)	< 0.001
Other ICU	235 (5%)	439 (7%)	< 0.001
ICU outcomes			
Mechanical ventilation, no. (%)	2014 (43%)	3223 (51%)	< 0.001
Median ICU stay in hours (IQR)	41.2 (22.3–65.9)	41.7 (21.7–73.3)	0.01
Median hospital stay in days (IQR)	9.9 (5.8–18.9)	9.0 (5.1–16.6)	< 0.001
ICU mortality, no. (%)	333 (7%)	423 (7%)	0.70
Hospital mortality, no. (%)	534 (11%)	672 (11%)	0.34

APACHE = Acute Physiology and Chronic Health Evaluation. ICU = intensive care unit.
IQR = interquartile range. ◆

blood cultures were blindly and independently reviewed by an infectious diseases specialist to identify any missing CLABSI cases.

Statistical analysis

Data were analysed using SAS, version 9.4 (SAS Institute). All data were visually assessed for normality using histograms. The primary outcome (CLABSI events) was compared first as an overall comparison of proportions and presented as a relative risk with 95% confidence intervals and second as the number of CLABSI events per quarter using Poisson regression.

Comparisons of pre- and post-intervention periods were performed for categorical variables using χ^2 tests

for equal proportions and reported as numbers (%). Normally distributed variables were compared using Student *t* tests and reported as mean (SD), and non-normally distributed data were compared using Wilcoxon rank-sum tests and reported as median (interquartile range). A two-sided *P* of 0.05 was considered to be statistically significant.

Results

Patient cohort characteristics are detailed in Box 1. The post-intervention cohort was significantly younger (mean age, 59.4 years v 64.2 years; *P* < 0.001) with a higher mean illness severity score (Acute Physiology and Chronic Health Evaluation

[APACHE] III score, 50 v 48; *P* = 0.001), an increased proportion of medical patients (3250/6273 [52%] v 1863/4701 [40%]; *P* < 0.001), an increased requirement for mechanical ventilation (3223/6273 [51%] v 2014/4701 [43%]; *P* < 0.001) and an increased admission source from the wards or emergency department. Although the clinical significance of the differences in age and APACHE score are questionable, when all differences are considered together, they favour an increased risk of CLABSI in the post-intervention cohort.

A total of 24783 central line days occurred between July 2006 and June 2014 (Box 2). Thirty cases of CLABSI were included in the analysis (eight did not satisfy CLABSI definition criteria and were excluded — seven pre-intervention and one post-intervention; Appendix 3). No CLABSI cases additional to VICNISS-reported cases were identified. In the pre-intervention period, there were 9844 central line days and 22 cases of CLABSI, resulting in a CLABSI rate of 2.2/1000 central line days. In the post-intervention period, there were 14939 central line days and eight cases of CLABSI, resulting in a CLABSI rate of 0.5/1000 central line days. This represents a rate ratio of 0.23 (95% CI, 0.11–0.54; *P* = 0.005). The temporal change in CLABSI rates is shown in Appendix 3, with a peak CLABSI rate of 5.2/1000 (4/766) central line days in quarter 4 of 2008, and a CLABSI rate of zero since June 2012. The difference in the quarterly CLABSI rate before and after the intervention was introduced was significant (*P* < 0.001), as was the difference in the number of quarters in which CLABSI rate was zero (pre-intervention, 3/14 v post-intervention, 12/18; *P* = 0.01).

The blood culture collection rate (60.1 [2827/4701] v 61.5 [3859/6273] per 100 patients) was similar in the pre- and post-intervention periods, while the positive culture rate significantly fell from 9.1% (258/2827) to 7.2% (279/3859) (*P* = 0.005) (Box 2). Characteristics of the confirmed CLABSI cases are presented in Box 3. The site of blood culture collection was similar between the two cohorts; however, no common skin commensals were isolated

as a causative organism in the post-intervention cohort.

Discussion

Our study describes a significant reduction in the CLABSI rate in a tertiary Australian Victorian ICU from a peak quarterly rate of 5.2 to zero after implementation of a care bundle that incorporated a novel line maintenance procedure. Overall, the CLABSI rate, per 1000 central line days, decreased from 2.2 in the pre-intervention period to 0.5 in the post-intervention period. In real terms, the reduced CLABSI rate equates to 15 fewer cases of CLABSI for the post-intervention period with an estimated total reduction in ICU length of stay of 38 days, hospital length of stay of 113 days and resultant cost saving of about \$210 000.

To our knowledge, this is the first time that a zero CLABSI rate has been achieved and sustained in an Australian ICU. Burrell and colleagues reported a CLABSI rate of 0.9/1000 central line days from several centres.⁷ Department of Health data from Western Australia have shown similarly low CLABSI rates, but their processes were not reported.^{5,7,24}

The finding of clinical effectiveness after introduction of the care bundle suggests that the observed benefits are causally associated. It is plausible that the maintenance procedure was crucial in reducing CLABSI, given that zero CLABSI was achieved despite the inclusion of lines inserted outside the ICU. It remains possible that changes in the patient cohort or procedures relating to CLABSI surveillance could account for the observed changes. In particular, there were seven CLABSIs that did not meet definition criteria in the pre-intervention period compared with one in the post-intervention period, raising the possibility of previous overreporting. Otherwise, the identified post-intervention cohort changes when taken together are considered as predisposing to CLABSI. In addition, the central line days and blood cultures per patient do not

2 Summary of total ICU patient admission, central line, blood culture and CLABSI data for the pre- and post-intervention periods

	Pre-intervention	Post-intervention	Rate ratio (95% CI)	P
Total patient days	8070	10 899		
Total central line days	9844	14 939		
Central line days per patient days	1.22	1.37		
Total blood cultures	2827	3859		
Blood cultures per patient days	0.35	0.36	1.01 (0.97–1.05)	0.59
ICU bacteraemia, no. (%)	258 (9.1%)	279 (7.2%)	0.79 (0.67–0.93)	0.005
CLABSI, no.	22	8	0.23 (0.11–0.54)	0.005
CLABSI rate per 1000 central line days	2.2	0.5		

CLABSI = central line-associated bloodstream infection. ICU = intensive care unit. ♦

support altered clinical practice as an explanation.

Our study's strengths include a large patient cohort with availability of population characteristics, a microbiological blood culture dataset, an independent review of all positive blood cultures, and the application of the current standard CLABSI definition across the entire study period. This reduces the likelihood that the observed change was driven by changes in non-infection control related clinical practices. This study is limited by a single-centre retrospective, observational design, limiting generalisability and the ability to establish causality. However, these limitations are largely comparable to prior similar studies.^{6,7,25} Other limitations included potential confounding from lines inserted outside the ICU and the absence of adherence data for the individual components of our line maintenance procedure to show actual change in clinical practice. However, in our experience, the care bundle has been embedded into routine and has markedly improved clinical practice.

In conclusion, our study suggests that a central line care bundle with this novel line maintenance procedure can effectively reduce the CLABSI rate to zero and that this zero CLABSI rate can be sustained. Validation of our study by other centres, especially if performed prospectively, would further support our findings.

Acknowledgements: We acknowledge Jill Low and Kaylene Styles for their expert infection control input in the development of the intervention bundle and for

3 Characteristics of CLABSI cases for the pre- and post-intervention periods

Characteristics of infected lines	Pre-intervention (n = 22)	Post-intervention (n = 8)
Line type, no. (%)		
CVC	21 (95%)	6 (75%)
Vascath	7 (32%)	3 (38%)
PAC	1 (5%)	1 (13%)
Other	3 (14%)	2 (25%)
Median dwell time, days (IQR)	6 (5–8)	5 (4–6)
Inserted in ICU, no. (%)	15 (68%)	7 (88%)
CLABSI organism, no. (%)		
<i>Staphylococcus aureus</i>	6 (27%)	2 (25%)
<i>Staphylococcus epidermidis</i>	6 (27%)	0
<i>Enterobacter</i> spp.	1 (5%)	2 (25%)
<i>Candida</i> spp.	6 (27%)	2 (25%)
<i>Enterococcus</i>	4 (18%)	1 (13%)
Other	2 (9%)	3 (38%)
Positive blood culture site, no. (%)		
Peripheral	5 (23%)	2 (25%)
Arterial	1 (5%)	0
Central	8 (36%)	2 (25%)
Unknown	19 (86%)	5 (63%)

CLABSI = central line-associated bloodstream infection. CVC = central venous catheter. ICU = intensive care unit. IQR = interquartile range. PAC = pulmonary artery catheter. ♦

providing surveillance data across the life of the study. We acknowledge Peter Stow for his support and input into the development and implementation of the intervention bundle.

Competing interests: No relevant disclosures.

Received 24 Nov 2014, accepted 9 Feb 2015. ■

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