A quality assurance investigation of CLABSI events: are there exceptions to never?

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Abstract

Background: In the USA, central line associated blood stream infections (CLABSIs) have been designated as ‘never events’, prompting initiatives towards a ‘zero CLABSIs’ standard. We propose that there are cascading risk factors pre-disposing certain patient cohorts to higher CLABSIs rates.

Methods: A retrospective review of all CLABSI infections over a 12-month period was undertaken. Risk factors examined included catheter type, insertion site and parenteral nutrition (PN) status. Additional factors analysed included acute kidney injury (AKI), chronic kidney disease (CKD) and hospital-acquired infections (HAIs).

Results: Thirty-four CLABSIs were identified in 33 adult patients (median age = 57 years). Temporary central venous catheters accounted for 12 (35%), peripherally inserted central catheters for five (14.7%), and permanent catheters for 17 CLABSIs (50%); the median duration from insertion was 15 days (interquartile range = 9–26). Among patient factors, immunosuppression and hyperglycaemia were the most common (n = 19, 55%), followed by PN and CKD (n = 17, 50.0%), AKI (n = 16, 47.1%) and HAIs (n = 13, 38.2%). A majority of patients with CLABSIs (n = 20 58.8%) had at least three risk factors.

Discussion: These findings reflect the complexity of CLABSIs with multiple patient and hospital factors influencing incidence. It suggests the need for further studies to re-calibrate the zero CLABSI model towards one with greater relevance.

Keywords

Central venous catheters, healthcare-associated infections, infection control

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Background

When the Center for Medicare and Medicaid Services’ (CMS) published its first list of diagnoses for non-payment in 2008, central line associated blood stream infections (CLABSIs) were initially identified as reasonably preventable hospital-acquired conditions. They have since acquired a designation of a ‘never event’, prompting insurance providers to adopt policies of non-payment for CLABSIs (Mattie and Webster, 2008). With each CLABSI estimated to cost \$25,000–32,000, healthcare systems have subsequently invested substantial time and resources to reduce CLABSIs (Stevens et al., 2014; Warren et al., 2006).

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Through the adoption of preventative bundles, improvements in catheter technology and staff education, hospitals have significantly reduced CLABSI rates (Klintworth et al., 2014; O'Grady et al., 2011; Pronovost et al., 2006; Zingg et al., 2011). Many institutions have also demonstrated that a zero CLABSI rate can be achieved through the implementation of structured quality improvement initiatives. Reports have demonstrated zero CLABSI rates for as long as 15 months in adults and 20 months in neonates (Erdei et al., 2015; Khalid et al., 2013).

Recently, there has been increasing debate about the sustainability of a rate of zero. Among those who have endeavoured to address this issue, it has been suggested that a zero CLABSI rate can only be maintained in a well-defined patient population (O'Grady, 2012; Worth and McLaws, 2012), such as in ICU patients who are immune competent and are not expected to have a prolonged need for a central venous catheter.

In an attempt to improve our CLABSI rate and enhance sustainability, we engaged in a quality assurance review of CLABSIs at our institution. We examined established risk factors associated with CLABSIs and further examined several potential risk factors. We further evaluated the number of risk factors per CLABSI, hypothesising that multiple patient- and hospital-associated risk factors are present in patients who develop CLABSIs.

Methods

Patient population

A quality assurance investigation was conducted in all adults (age ≥ 18 years) with a CLABSI identified from January to December 2014 at a 1147-bed urban tertiary hospital in the United States. CLABSI events were defined by the current Center for Disease Control and Prevention (CDC) criteria and identified by an infection control team led by a hospital epidemiologist (Center for Disease Control and Prevention, 2017). A chart review was subsequently conducted examining well established risk factors, including anatomical insertion site, duration of catheter, hospital ward location (ICU versus non-ICU), parenteral nutrition, renal disease, immunosuppression, history of transplant, tissue plasminogen activator (tPA) for suspected line thrombosis and concomitant hospital-acquired infections (HAIs) (Ippolito et al., 2015; Pepin et al., 2015; Thakrar et al., 2014). Additional patient factors, thought to potentially influence the development of a CLABSI, were examined. Included among these were diabetes mellitus (DM), hyperglycaemia, lower extremity peripheral arterial disease (PAD), short bowel syndrome (SBS), limited central venous access and end-of-life care/comfort care.

Catheters

Catheters were categorised as temporary (triple lumen catheters [TLC], haemodialysis catheters [HD] and peripherally inserted central catheters [PICCs]) or permanent (Hickmans, Port-a-Caths, permacaths and Broviacs). Anatomical insertion sites included internal jugular, subclavian, femoral, basilic and brachial veins.

Definitions

Duration of catheter insertion was calculated according to CDC criteria, where day of insertion corresponded to day 1. Renal disease was defined as acute kidney injury (AKI) and/or chronic kidney injury (CKD) according to the Kidney Disease: Improving Global Outcomes (KDIGO) criteria (KDIGO Acute Kidney Injury Work Group, 2012; KDIGO CKD Work Group, 2013). Immunosuppression was designated in patients with chronic steroid use, immunoglobulin deficiency, undergoing chemotherapy, having received a transplant and/or having neutropenia. Transplants performed in our population included heart, kidney, liver, small bowel, bone marrow, peripheral blood stem cell and umbilical cord blood. Alteplase was the only tPA administered at our institution.

HAIs examined in this study included hospital-acquired pneumonia, ventilator-associated events, catheter-associated urinary tract infections, surgical site infections, hospital-associated *Clostridium difficile* colitis and blood stream infections excluding the primary CLABSI identified. Bacterial resistance was defined according to the European Centre for Prevention and Control and CDC (Magiorakos et al., 2012). Multidrug-resistant (MDR) bacteria were defined as non-susceptible to ≥ 1 agent in ≥ 3 antimicrobial categories. Extensively drug-resistant (EDR) bacteria were characterised as non-susceptible to ≥ 1 agent in all but ≤ 2 categories and pan-drug-resistant (PDR) bacteria were non-susceptible to all available antimicrobial agents.

DM was defined according to the American Diabetes Association's 2015 criteria (American Diabetes Association, 2015). Hyperglycaemia was designated as two or more glucose values greater than 7.8 (mmol/L). Lower extremity peripheral arterial disease was defined according to the American Heart Association and American College of Cardiology Foundation guidelines (Anderson et al., 2013; Hirsch et al., 2006). Short bowel syndrome was characterised according to the American Gastroenterological Association (O'Keefe et al., 2006). Patients were considered to have limited central venous access if two or more major access points (internal jugular, subclavian or femoral veins) were not accessible due to stenosis, thrombosis, infection, surgical site or anatomical variation. End-of-life care/comfort care was designated when death was felt to be inevitable and the decision to focus only on comfort

Table 1. Demographics and distribution of CLABSI by category of central catheter.

	Temporary	Permanent	Total
Age (years) (mean)	62.4 (range = 18–92)	53.5 (range = 20–80)	58 (range = 18–92)
Gender			
Male	9	10	19
Female	8	7	15
Days hospitalised (median)	40.0 (IQR = 46.5–83.5)	39.0 (IQR = 20.5–68)	39.5 (IQR 21–66)
Anatomical location			
Internal jugular	11	13	24
Subclavian	1	4	5
Brachial	3	–	3
Basilic	1	–	1
Femoral	1	–	1

IQR: interquartile ranges

measures was collectively made by the patient/family and primary team.

Statistical analysis

Data were collected and recorded using Microsoft Excel software. Statistical analyses were performed using SAS software version 9.4. Descriptive statistics were produced with categorical variables reported as percentages and continuous variables reported as means or medians as appropriate with ranges and interquartile ranges (IQR). Comparison of the characteristics of CLABSI occurring with temporary versus permanent catheters was made using Chi-square tests for categorical variables and t-test for continuous variables.

Results

Demographics

In 2014, there were 2018 central venous catheters placed in adults at our institution. Thirty-four CLABSI developed in 33 adults (mean age = 58 years, age range = 18–92 years; IQR = 48–73) corresponding to an incidence of 0.5 CLABSI per 1000 central line days. Four of the 33 patients had central lines placed at outside institutions. Nineteen CLABSI occurred in men (55.9%). The median hospital length of stay was 39.5 days (range = 9–369; IQR = 21–66) (Table 1).

In both the temporary and permanent catheters, the internal jugular vein was the most commonly accessed vessel (Table 1). Femoral access was associated with one CLABSI. Two of the temporary catheters were placed emergently, but under sterile conditions.

Microbiology

The most commonly identified organisms were gram-positive bacteria, followed by gram-negative bacteria and

fungi (Table 2). Six of the CLABSI were polymicrobial. *Staphylococcus aureus* was the most commonly identified gram-positive bacteria (n = 11), 63.6% being MRSA (n = 7). Two vancomycin-resistant enterococci (VRE) were found; one isolate was extensively resistant. Two of the gram-negative bacteria isolates were extended spectrum beta-lactamase (ESBL) producers.

Catheter characteristics

CLABSI were equally distributed between temporary (n = 17) and permanent (n = 17) catheters, with the highest incidence in TLCs and Hickman catheters, respectively (Table 3). In the temporary catheters, the median number of days from insertion to positive culture was shortest for HD catheters with 6.5 days (range = 7–26 days). Excluding the single Broviac catheter, Port-a-Caths had the shortest duration with 14 days (range = 3–16 days) from access to positive culture among the permanent catheters.

Established and potential risk factors

Comparison of CLABSI in the temporary catheter group with those in the permanent catheter group showed similar distribution of the following established risk factors: total parenteral nutrition, chronic kidney disease, acute kidney injury, immunosuppression, history of transplant and other HAIs (Table 4). In the ICU setting, there appeared to be disproportionately more CLABSI in the temporary catheter group compared with the permanent catheter group; however, this was not statistically significant.

In the potential risk factors investigated, hyperglycaemia was the most prevalent, occurring in 20 of the 34 CLABSI (Table 5). Among these patients, 12 were receiving TPN. The presence of DM, however, was only present in seven CLABSI.

Table 2. Organisms identified in the CLABSI.

	Total (+) cultures	MDR (%)
Gram-positive bacteria	30	19 (63.3)
<i>Staphylococcus aureus</i>	11	7
<i>Staphylococcus epidermidis</i>	9	6
<i>Staphylococcus haemolyticus</i>	4	2
<i>Staphylococcus hominis</i>	2	2
<i>Enterococcus faecium</i>	2	2
<i>Enterococcus gallinarum</i>	1	0
<i>Lactobacillus casei</i>	1	0
Gram-negative bacteria	7	2 (28.6)
<i>Pseudomonas aeruginosa</i>	2	0
<i>Escherichia coli</i>	1	0
<i>Klebsiella oxytoca</i>	1	0
<i>Klebsiella pneumonia</i>	1	1
<i>Proteus mirabilis</i>	1	1
<i>Stenotrophomonas maltophilia</i>	1	0
Fungi	6	—
<i>Candida albicans</i>	2	0
<i>Candida parapsilosis</i>	2	0
<i>Candida dubliniensis</i>	1	0
<i>Candida glabrata</i>	1	0

MDR: Multidrug-resistant

The mean total number of established risk factors was identical between the temporary and the permanent catheter groups (mean = 3.4 for both; $P = 0.00$). Two or more of these risk factors were present in 29 of the 34 CLABSI (85.3%); three or more were present in 20 of the 34 CLABSI (58.8%) (Figure 1).

Discussion

Akin to other institutions, our hospital system has invested substantial time and financial resources into reducing CLABSI, simultaneously focusing on the ultimate goal of achieving a rate of zero. In 2005, our hospital established a quality assurance CLABSI committee, comprising physicians, mid-level providers, nurses and administrators to monitor, strategise and implement measures at a systems level to reduce CLABSI. As a result, numerous performance improvement initiatives were deployed. These included an emphasis on hand hygiene (Sax et al., 2007), empowering nursing staff to perform safety checklists and

Table 3. Distribution of CLABSI among temporary and permanent catheters and the mean number of days from insertion/access to positive culture.

	Number	Insertion/Access to positive culture (median days; range)
<i>Temporary (n = 17)</i>		
TLC	8	12.0 (7–26)
HD	4	6.5 (3–15)
PICC	5	38.0 (10–81)
<i>Permanent (n = 17)</i>		
Hickman	7	22.5 (11–418)*
Port-a-Caths	5	14 (3–16)
Permacaths	4	34.5 (7–78)
Broviac	1	11.0

*Information regarding access was not available for one CLABSI in the Hickman group.

pause procedure in case of violations, avoidance of the femoral vein, daily dressing assessment, daily line necessity assessment (via automated EMR notification), daily chlorhexidine bathing for patients with central venous catheters and increased attention to line maintenance (i.e. Biopatch, alcohol impregnated caps on unused ports, needleless connectors). Central to deploying each initiative was education at all levels, including environmental services, house staff, nurses, mid-level practitioners, medical assistants, attending physicians and ancillary staff.

From 2011 to 2014, these performance improvement measures resulted in a considerable decrease in CLABSI. From 2012 to 2013, the incidence went from 1.7 to 0.8 CLABSI per 1000 central line days, nearly a 53% reduction. The following year, CLABSI were further reduced to 0.5 CLABSI per 1000 central line days. Although notable, the reduction was only 37.5% compared with the prior year. These outcomes prompted a rigorous quality assurance investigation of our institution's CLABSI to critically assess for deficiencies and develop strategies for improvement.

The critical review of the 34 CLABSI that occurred at our institution in 2014 demonstrated similar population demographics to previously published data (Pepin et al., 2015; Stevens et al., 2014). While CLABSI occurred more commonly in men ($n = 19$, 55.8%) this did not reach statistical significance ($P = 0.73$). The distribution of organisms identified in our CLABSI mirrored previously reported studies, with gram-positive bacteria being the most prevalent, followed by gram-negative bacteria and fungi (Fontela et al., 2012; Nemoto et al., 2015).

Our analysis further revealed that CLABSI were most frequently associated with internal jugular vein access in both temporary and permanent catheters (70.6%). In our patient population, this anatomical site distribution can be

Table 4. Distribution of established risk factors in CLABSI between temporary and permanent catheters.

	Immuno-suppression	CKD	TPN	AKI	HAI	Transplant	ICU	tPA
Temporary, n = 17 (%)	9 (52.9)	8 (47.1)	7 (41.1)	9 (52.9)	8 (47.1)	7 (41.1)	8 (47.1)	1 (5.9)
Permanent, n = 17 (%)	11 (64.7)	9 (52.9)	10 (58.8)	7 (41.1)	7 (41.1)	5 (29.4)	3 (17.6)	6 (35.3)
Cumulative, n = 34 (%)	20 (58.8)	17 (50.0)	17 (50.0)	16 (47.1)	15 (44.1)	12 (34.3)	11 (32.4)	7 (20.6)

CKD: chronic kidney disease; TPN: Total parenteral nutrition; AKI: acute kidney injury; HAI: hospital-acquired infections; ICU: intensive care unit; tPA: tissue plasminogen activator

Table 5. Distribution of potential risk factors in CLABSI between temporary and permanent catheters.

	Hyperglycaemia	Limited access	DM	SBS	Comfort care	PAD
Temporary, n = 17 (%)	12 (70.6)	5 (29.4)	3 (17.6)	2 (11.8)	3 (17.6)	1 (5.9)
Permanent, n = 17 (%)	8 (47.1)	6 (35.3)	4 (23.5)	5 (29.4)	3 (17.6)	2 (11.8)
Cumulative, n = 34 (%)	20 (58.8)	11 (32.4)	7 (20.6)	7 (20.6)	6 (17.6)	3 (8.8)

DM: diabetes mellitus; SBS: short bowel syndrome; PAD: peripheral arterial disease

Figure 1. Distribution of the cumulative number of established risk factors in patients with CLABSI.

attributed to multiple factors. Specifically, the femoral vein was avoided as dictated by our CLABSI committee. The patient population also possessed several co-morbidities (i.e. coagulopathy, renal disease), which created a preference for the internal jugular over the subclavian vein. The high incidence of CLABSI associated with internal jugular vein access can also be attributed to house staff education. At our institution, there has been universal adoption of ultrasound for central venous catheter placement, which is most easily applied during cannulation of the internal jugular and femoral veins.

During our investigation, several unexpected findings were revealed. Notably, the number of CLABSI was evenly distributed between temporary (n = 17) and permanent catheters (n = 17). Previous literature has ascribed higher rates of infection in temporary catheters when compared with

permanent catheters (O'Grady, 2012). This finding prompted our CLABSI committee to critically evaluate access and maintenance of permanent catheters at our institution. This investigation revealed a gap in our inpatient maintenance of permanent catheters. Specifically, it was discovered that patients with permanent catheters were only having dressing changes performed by dialysis nurses resulting in delays in their routine maintenance. Consequently, a new inpatient policy for permanent catheters was developed in conjunction with competency training for all floor nurses to ensure that all nurses were certified in the cleaning and change of dressing for permanent catheters.

One of the most remarkable findings of the analysis was the cumulative number of established risk factors identified in each patient. Both temporary and permanent catheter groups demonstrated a mean of 3.4 established CLABSI

risk factors. Among all CLABSI, 85.3% of the patients had ≥ 2 and 58.8% had ≥ 3 established risk factors. There were zero patients with zero established risk factors.

Among the potential risk factors, hyperglycaemia was the most prevalent, occurring in 58.8% of CLABSI. As evidenced by the growing body of literature, hyperglycaemia has been associated with adverse outcomes (i.e. increased mortality and infection rates) in critically ill and surgical patients (Ito et al., 2014; Lazar et al., 2009; Ramos et al., 2008). No studies have identified a relationship between hyperglycaemia and CLABSI; however, our findings suggest that one may exist. The presence of hyperglycaemia in the setting of a CLABSI may be a reflection of the stress response induced by illness. Conversely, hyperglycaemia may be entertained as a potentially modifiable CLABSI risk factor. Further investigation of this association is warranted.

The prevalence of the inherently intrinsic risk factors demonstrated in our patient population forces a sombre question: are there exceptions to 'never'? Multiple studies have shown that through the implementation of education and best practice bundles, CLABSI rates can be markedly reduced and a goal of zero can be achieved. However, no study has demonstrated indefinite sustainability of a rate of zero. We propose that a new weighted national standard be considered that incorporates patient risk factors and emphasises sustainability. A new weighted standard would dictate the lowest achievable rate in a defined timeframe.

This quality assurance investigation has intrinsic limitations. Specifically, as a retrospective analysis there was not a control group for comparison, limiting the ability to fully evaluate potential CLABSI risk factors. Furthermore, the population examined was small. It should also be noted that CLABSI, rather than catheter-related blood stream infections (CRBSIs), were examined. This may have resulted in over-reporting of infections, as catheter tips were not cultured to definitely diagnose infections due to catheters. Conversely, under-reporting may have occurred due to the stigma associated with a CLABSI. A future prospective study examining a larger population against a control population would provide greater insight into the potential risk factors associated with CLABSI.

Collectively, our findings demonstrate that CLABSI are complex entities, with multiple patient and hospital risk factors occurring simultaneously. Furthermore, risk factors appear to vary from one patient to another, making it an individualised event. In attempt to mitigate these risks and reduce CLABSI, we recommend that institutions establish and maintain a CLABSI committee led by an infection control team to critically evaluate these events on an annual basis.

Conclusion

Through our quality assurance investigation, we demonstrated that multiple risk factors occur simultaneously in

CLABSI. We further identified hyperglycaemia as a potential CLABSI risk factor that warrants further examination. Undeniably, the zero CLABSI movement has had marked success. However, we propose that the goals of the CLABSI movement be reassessed and that a new weighted standard that incorporates patient risk factors and emphasises sustainability be considered.

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