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Short Report

The effectiveness of a dedicated central venous access care team to prevent catheter-related bloodstream infection in a private hospital☆

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SUMMARY

Objective: We hypothesized a dedicated team would decrease catheter-related bloodstream infection (CRBSI) rates.
Method: We implemented a before-after study.
Results: CRBSI frequency (39/103 vs. 28/105, P=0.084) and incidence (36.61/1000 vs. 26.1/1000 catheter-days, *P*=0.175) were lower in the intervention arm.
Conclusion: The intervention delayed median time to CRBSI, but was insufficient to decrease overall rates.

Introduction

Catheter -related blood stream infections (CRBSIs) cause excessive morbidity, are associated with substantial economic costs, and can potentially be lethal [1]. To help decrease the risk of CRBSIs, the Institute of Healthcare Improvement created the CRBSI bundle. The bundle is made up of several elements including hand hygiene, appropriate site selection, chlorhexidine use, aseptic technique, maximum barriers, and prompt line removal. It has proven successful in several hospitals, and is the standard of care for CRBSI prevention [2]. More recent studies also emphasize the importance of multiple interventions, as well as use of maintenance bundles [3,4] to prevent CRBSIs.

Abbreviations: CVC, Central venous catheter; CRBSI, Catheter Related Blood Stream Infection; CVAT, Central Venous Access Team; ICU, Intensive Care Unit; NIC, Nurse in charge.

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At our institution, CRBSIs were frequently identified despite introduction of the CRBSI bundle in 2014. We hypothesized that the true incidence of CRBSI was underestimated. We conducted a quasi-experimental before − after study to 1) document the hospital-wide incidence density and 2) show that a dedicated central venous access team (CVAT) could help decrease CRBSI rates.

Methodology

Study setting

Our institution is a 526 bed-capacity hospital in Pasig City, Philippines. Limited CRBSI surveillance is performed in the ICU given resource limitations. New nurses undergo basic skills training but more advanced CVC training occurs once they are regular employees (e.g. >2 years). Approximately 30−40% of nurses in the medical-surgical floors have <2 years of experience; more experienced nurses are assigned to specialty units (e.g. Oncology). Physicians (e.g. critical care specialists, surgeons) undergo CVC training separately, under their respective sections.

Study design and population

We implemented a 14 month before (September 1st, 2020 through March 31st, 2021) and after (April 1st-October 31st, 2021) quasi-experimental study during the COVID-19 pandemic. All adult in-patients with newly inserted temporary CVCs were eligible for inclusion; for patients with multiple catheters, each catheter was treated separately. Patients with pre-existing CVCs (>48 hours) were excluded. This study was a quality improvement project approved by the Institutional Review Board (IRB # 2019-061).

Standard of care and intervention (CVAT team)

The current standard of catheter insertion, maintenance and care is based on international and institutional guidelines (Supplementary Appendix 1 and 2). The CVAT, composed of two infection control nurses trained in CVC care (Supplementary Appendix 3) performed daily rounds, CVC needs assessment, and dressing changes. They provided education, feedback, and reported observations (e.g. loose or soaked dressing, occluded ports, etcetera) in writing or verbally to the nurse in charge (NIC) and healthcare team (e.g. including physicians). Compliance with catheter care guidelines was assessed only periodically, during rounds with the NIC. The CVAT was available daily from 9AM- 6PM except on Sundays. Daily catheter handling continued to be performed by the team that inserted the catheter or NIC as needed.

Data collection and management

Consecutive temporary CVCs inserted during the pre-intervention study period outside of the ICU were collected retrospectively by reviewing multiple records and databases (e.g. nurses and surgical records, microbiology data, medical charts); pre-intervention ICU data and all intervention data were collected prospectively. Baseline patient demographics and CVC-related data were reviewed using health records, and encoded using a standard data collection form. Data were de-identified and aggregated in a secure file accessible only to investigators.

Outcomes

CRBSI was defined using standard definitions [1,5] as follows: 1) Differential time to positivity (DTP) with simultaneous blood cultures drawn from the CVC and a peripheral site, with the DTP considered positive if growth of bacteria from the CVC was >120 min earlier than the peripheral site; OR 2) any growth of pathogenic bacteria from the CVC, OR 3) growth of identical pathogens from the CVC and the catheter segment or tip. Growth of non-pathogenic bacteria such as coagulase negative staphylococcus, *Bacillus* sp., or other similar species, could be considered as CRBSI after review of records.

The primary outcome was incidence density of CRBSI (e.g. # infected catheters/1000 catheter days). Secondary outcome included time to CRBSI.

Statistical analysis

Based on anecdotal data and institutional experience, we assumed 1 CRBSI event for every 5 CVCs inserted (e.g., 20%) and that the CVAT could decrease the incidence by half (e.g.10%). Based on these assumptions, for a desired power of 0.80 and a Type I error rate of 0.05, we estimated 199 catheters in each arm to detect a difference.

Descriptive statistics was used to summarize the clinical characteristics of the patients. Continuous quantitative data were summarized using median and interquartile range. The non-parametric Mann-Whitney U test was used to compare skewed quantitative data. Categorical variables were compared using Chi-square test or Fisher's Exact test as appropriate. The Cox proportional hazards model was applied for univariable and multivariable analyses to determine the risk factors contributing to development of CRBSI. Variables that were either proven or considered to be related to the outcome based on published literature were chosen for the analyses. Null hypothesis was rejected at 0.05 α-level of significance. STATA version 15.0 (StataCorp SE, College Station, TX, USA) was used for data analysis.

Results

Characteristics of the cohort

Only 208 patients were enrolled in the study, with 103 (49.28%) CVCs in the pre-intervention, and 105 (50.72%) in the intervention arms. Baseline patient characteristics including age (61.6 vs 62.9 years), gender (male, 59.22% vs. 50.94%), presence of cardiac comorbidity (34% vs. 39%), and primary indication for CVC (intravenous access 78% vs. 73%) were similar in both groups. Renal disease was more common in the pre-intervention arm (43% vs. 19%, $P < 0.001$), while COVID-19 (39% vs. 21%, $P = 0.006$) and diabetes mellitus (33% vs. 20%, $P = 0.035$) were significantly more frequent in the intervention arm. (Table I).

Characteristics of central venous catheters

In both pre and intervention groups, the preferential site for CVC insertion was the internal jugular vein [70 (67.96%) vs. 79 (75.24%)]. Most central line placements were performed in the operating room by surgery (63, 61.17%) during the pre-intervention period, but were performed in the ICU at

bedside (70, 67%) during the intervention period (Table 1). CVC use for IV fluids and medications, chemotherapy, and renal replacement therapy were comparable among patients in the two arms. In contrast, central line use for blood transfusions (15% vs 0%) and parenteral nutrition (34% vs 3%) were more frequently reported in the pre-intervention period (Table 1).

Microbiology

In both pre- and intervention groups, Gram-negative organisms were responsible for half of CRBSIs (43.59% vs. 50%), while *Staphylococcus* sp. was the most common gram-positive organism in both groups. Majority fulfilled CRBSI diagnosis with growth of organism from the CVC alone (n=30), or via DTP (n= 19). A complete list of organisms and method of diagnosis is in Supplementary Appendix 4.

Outcomes

There were more frequent CRBSI's in the pre-vs. intervention arm (39/103 vs. 28/105, P =0.084). The CRBSI incidence density rate was higher in the pre-vs. intervention arm, but was not statistically significant (37.86/1000 catheter-days vs. 26.67/1000 catheter-days, P =0.175). The median time to development of CRBSI was shorter with the pre-intervention (between 13 to 15 days) than in the intervention group (between 16 to 17 days) (Supplementary Appendix 5).

Table I
Characteristics of the study cohort

	All (n=208)	Pre-CVAT (n=103)	CVAT (n=105)	*P*
	Median (interquartile range); frequency (%)			
Age (years)	63 (51—74)	62 (52—73)	64 (51—78)	.448[a]
Sex				.205[b]
Male	114 (54.81)	61 (59.22)	53 (50.48)	
Female	94 (45.19)	42 (40.78)	52 (49.52)	
Comorbidities				
Cardiac disease	76 (36.54)	35 (33.98)	41 (39.05)	.448[b]
Diabetes mellitus	56 (26.92)	21 (20.39)	35 (33.33)	**.035**[b]
Renal disease	64 (30.77)	44 (42.72)	20 (19.05)	**<.001**[b]
Others	136 (65.38)	87 (84.47)	49 (46.67)	**<.001**[b]
Main reason for CVC				.467[b]
Intravenous access	157 (75.48)	80 (77.67)	77 (73.33)	
Hemodialysis	51 (24.52)	23 (22.33)	28 (26.67)	
Specific purposes of CVC				
IV fluids/medications	154 (74.04)	72 (69.90)	82 (78.10)	.178[b]
Blood transfusion	15 (7.21)	15 (14.56)	0 (0)	**<.001**[b]
Chemotherapy	35 (16.83)	19 (18.45)	16 (15.24)	.536[b]
Renal replacement	51 (24.52)	23 (22.33)	28 (26.67)	.467[b]
Parenteral nutrition	38 (18.27)	35 (33.98)	3 (2.86)	**<.001**[b]
CVC insertion setting				**<.001**[b]
ICU	110 (52.88)	40 (38.83)	70 (66.67)	
OR	98 (47.12)	63 (61.17)	35 (33.33)	
COVID-19 status				**.006**[b]
COVID	63 (30.29)	22 (21.36)	41 (39.05)	
Non-COVID	145 (69.71)	81 (78.64)	64 (60.95)	
Vascular access				.285[b]
Arm vein	28 (13.46)	16 (15.53)	12 (11.43)	
Femoral vein	13 (6.25)	5 (4.85)	8 (7.62)	
Internal jugular vein	149 (71.63)	70 (67.96)	79 (75.24)	
Subclavian vein	18 (8.65)	12 (11.65)	6 (5.71)	
Catheter duration	8 (4—16)	8 (4—21)	8 (4—14)	.602[a]
ICU admission	134 (64.42)	55 (53.4)	79 (75.24)	**.001**[b]
Length of stay (days)				
ICU	10 (4—20)	10 (4—25)	10 (4—19)	.806[a]
Still admitted	3 (2.24)	0 (0)	3 (3.80)	
Hospital	17 (9—34)	22 (8—43)	15 (10—28)	.245[a]
Still admitted	8 (3.85)	0 (0)	8 (7.62)	

CVC — central venous catheter; ICU — intensive care unit; PICC - peripherally inserted central catheters; OR-operating room.
Statistical tests used
[a] Mann-Whitney U test. Bold value signifies statistically significant (P<0.05).
[b] Chi-square test.

Characteristics of patients with and without CRBSI's

Patients who developed CRBSI were more likely to have underlying renal disease [31 (46.27%) vs. 33 (23.24%), $P = 0.01$]; have a CVC for a longer period of time [12 (7–21) vs. 6 (3–12) days, $P = 0.01$]; and more likely to have been in the ICU [53 (79.10%) vs. 81 (57.45%), $P = 0.01$]. CVCs inserted for chemotherapy were less likely to develop CRBSI [31 (21.99%) vs 4 (5.97%), $P = 0.04$]. (Table II).

On univariate analysis, underlying renal disease (cHR 1.8) and hemodialysis (cHR 1.9) were associated with increased hazard for developing CRBSI. After adjusting for other covariates, no factors in the model were significantly associated with CRBSI (Supplementary Appendix 6).

Discussion

We gained a better idea of our baseline CRBSI-rates through this study. Our rates were much higher compared to the region (4.19/1000 catheter days). [6] We broadly defined CRBSI using 3 different criteria [7], which may have overestimated rates of infection. If we limit the definition strictly to those who fulfilled DTP criteria (n=19), a commonly used method with relatively high specificity (81%), the rates fall to 9.6/1000 catheter days and 8.4/1000 catheter days, in the pre-intervention and intervention arm respectively, which are more comparable to the region, but still high overall. We decided to use all 3 criteria, however, to increase sensitivity and capture all potential CRBSI.

Table II
Characteristics of patients with and without CRBSI (n=208)

	-CRBSI (n=141)	+CRBSI (n=67)	*P*
	Frequency (%); median (IQR)		
Age	64 (19–99)	60 (19–91)	.139
Sex			.116
Male	72 (51.06)	42 (62.69)	
Female	69 (48.94)	25 (37.31)	
Comorbidities			
Cardiac disease	49 (34.75)	27 (40.3)	.438[b]
Diabetes mellitus	36 (25.53)	20 (29.85)	.512[b]
Renal disease	33 (23.4)	31 (46.27)	**.001**[b]
Others	91 (64.54)	45 (67.16)	.710[b]
Main reason for CVC			.588[b]
Intravenous access	108 (76.60)	49 (73.13)	
Hemodialysis	33 (23.40)	18 (26.87)	
Specific purposes of CVC			
IV fluids/medications	94 (66.67)	60 (89.55)	**<.001**[b]
Blood transfusion	11 (7.8)	4 (5.97)	.778[c]
Chemotherapy	31 (21.99)	4 (5.97)	**.004**[b]
Renal replacement	33 (23.4)	18 (26.87)	.588[b]
Parenteral nutrition	21 (14.89)	17 (25.37)	.068[b]
Vascular access			.811[b]
Arm vein	19 (13.48)	9 (13.43)	
Basilic (BICC)	3 (2.13)	5 (7.46)	
Brachial	1 (0.71)	1 (1.49)	
Cephalic	6 (4.26)	0 (0)	
Unspecified	9 (6.38)	3 (4.48)	
Femoral vein	9 (6.38)	4 (5.97)	
Internal jugular vein	99 (70.21)	50 (74.63)	
Subclavian vein	14 (9.93)	4 (5.97)	
Catheter duration (days)	6 (3–12)	12 (7–21)	**<.001**[a]
ICU admission	81 (57.45)	53 (79.10)	**.002**[b]

Statistical tests used.Bold value signifies statistically significant ($P<0.05$).
[a] Mann-Whitney U test.
[b] Chi-square test.
[c] Fisher's Exact test.

We hypothesize that since infection is extraluminal in origin for short term catheters [8], the daily catheter manipulation by untrained staff, including physicians, predisposed them to infection. Second, we surmise that inexperience or rapid nurse turn-over played a role in catheter care [9]. CVC's inserted in the Oncology floor, where nurses are traditionally more experienced, were less likely to get infected [4 (5.97%) vs. 30 (21.13%) $P=0.01$]), compared to lines inserted for IV fluids [94 (66.67) vs.60 (89.55), $P<.001$] in the general medical floor or ICU, giving credence to our theory.

Central venous catheters left in place for a prolonged period (12 vs 6 days) were more likely to get infected, highlighting the need to assess the CVC daily. Interestingly, median time to CRBSI occurred later in the intervention arm. This suggests that the CVAT, with their daily needs-assessment may have mitigated the risk of infection.

In this study, hemodialysis and underlying renal disease appeared to be associated with development of CRBSI over time. HD lines included in this study were used for multiple purposes such as IV access, medications, pressor support, and blood transfusions. The daily manipulation and handling likely contributed to the increased risk of infection. Ideally, HD lines should be dedicated for HD access alone, but other purposes may be unavoidable in certain circumstances —when there are vascular issues, or other access is difficult to find. Given these findings, we recommend that future CRBSI preventive efforts should focus in the ICU, where HD lines are typically used for multiple purposes.

Dedicated CVC teams were successful in other institutions. [10,11] We chose this as our intervention because other methods (e.g. antibiotic lock therapy or antibiotic impregnated devices) are costly. Unfortunately, our study was underpowered, as it inaugurated during the COVID-19 pandemic, when patient admissions were low, likely contributing to the negative results. Prolonging the duration of the study would have been ideal, but could not be done due to lack of funds and resources. Despite this, however, there was still a decrease in the frequency and rate of CRBSIs, and a longer median time to CRBSI during intervention. For future studies, we recommend an adequately powered study and a multi-modal approach, with focus on staff education, including observation of compliance to the CRBSI insertion bundle, and hands-on training.

Our study has several limitations inherent to its study design. The lack of randomization (e.g. not all physicians or patients consented to enroll in the study), retrospectively reviewed data, and the quasi-experimental nature of the study (e.g. 2 different time periods) could have introduced bias. To minimize this, however, standard definitions of CRBSI were used. There are also threats to external validity including sampling bias (e.g. long-term tunneled lines were not included), situation effect (e.g. COVID-19 pandemic), and history of catheter manipulation (e.g. CVC care by other personnel, such as clinicians, could not be controlled for each patient). The high baseline rates may also make regression to the mean a possible explanation for the decrease in number during the

intervention arm. Despite these limitations, this study can guide future quality improvement initiatives including the need to monitor bundle compliance. In conclusion, the use of a dedicated CVAT delayed the onset of CRBSI, but was insufficient to decrease CRBSI rates, likely due to inadequate power.

Author contributions

Cybele Abad, Jia Bello: Conceptualization, Methodology, Writing- original draft; Ma. Jesusa Mano, Fortune Charles de Lara, Jia Bello, Ma. Cristina Perez: Data curation, investigation, resources, writing- original draft preparation. Cybele Abad: Supervision; writing-review and editing.

Ethical approvement statement

The work described was carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans. Informed consent was waived and the study was approved by the Institutional Review Board of TMC.

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Conflicts of interest

All authors report no conflicts of interest relevant to this article.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.infpip.2022.100259.

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