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ORIGINAL ARTICLE

Peripheral Venous Catheter-Associated Bloodstream Infections (PVC-BSI) Risk Compared With Central Line-Associated Bloodstream Infections (CLABSI)

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Highlights

- The rates of PVC-BSI and CLABSI were comparable outside of the ICU setting.
- The risk of *Staphylococcus aureus* bacteremia was greater in PVC-BSI.
- An EMR-based PVC-BSI active surveillance program is achievable in most hospitals.

Abstract

We compared the risk of peripheral venous catheter (PVC) bloodstream infection (BSI) to central line-associated BSI (CLABSI) at University of California San Diego Health. The rates of PVC-BSI and CLABSI were comparable outside of the intensive care unit setting, and the risk of *Staphylococcus aureus* bacteremia was greater in PVC-BSI.

Keywords: catheter, bloodstream infection, peripheral venous catheter, bacteremia

Introduction

Peripheral venous catheters (PVCs) are among the most widely used medical devices in hospitals.[1,2] Approximately 200 million PVC devices are used each year on adults in the United States.[3] The incidence of PVC-related bloodstream infections (BSIs) is estimated to be 0.18%. Overall, the risk of catheter-related BSIs has been reported to be greater in central venous catheters (CVCs) than PVCs,[3] but CVCs are used less frequently in acute care settings than PVCs.[1] Since PVC use greatly exceeds central lines, the prevalence of PVC-BSIs may be significant.[3] Most studies and clinical guidelines, however, have focused on reducing CVC-related BSIs.[4] The Infusion Nurses Society guidelines recommend surveillance for PVC-related BSIs,[5] but few facilities in the US report compliance. The intent of this study was to compare the risk of PVC-BSI to central line-associated BSI (CLABSI) at University of California San Diego Health (UCSDH) and to identify any opportunities for improvement.

Methods

A case control study was conducted at UCSDH, a 2-hospital, 808-bed quaternary care academic health system in San Diego, CA. A patient line list was generated from EPIC electronic medical records (EMR) with an abnormal blood culture result and an eligible PVC without the presence of a central line between December 2020 and August 2021. Monthly line lists included data from the patients' line/drains/airways flowsheet consisting of patient admission, disposition, location during

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line insertion, PVC insertion time, site location, line removal time, and daily assessment. Patients were classified as cases if they were determined to have a PVC-BSI according to the inclusion criteria below.

Inclusion Criteria

PVC-BSIs were identified using the National Healthcare Safety Network (NHSN) criteria for a bloodstream infection event.[6] The NHSN CLABSI criteria consist of an eligible central line and an eligible BSI organism. PVC-BSIs were identified using the same definition. An eligible PVC line was defined as one that had been in place for more than 2 consecutive calendar days, in an inpatient location, during the current admission. PVC-BSIs were only considered if they were health care-associated infections (HAIs) on or after day 3 from hospital admission (hospital onset). A HAI PVC-BSI is possibly associated if a positive blood culture was identified more than 2 days after admission (day 1 being the day of admission). The association of a device was considered if (1) a recognized bacterial pathogen not included on the NHSN common commensal list was identified from a blood culture, and the organism was not related to an infection at another site, or (2) the same common commensal was identified in 2 or more blood cultures collected on separate occasions, and the patient had at least 1 of the following symptoms: fever, chills, or hypotension.

Exclusion Criteria

Patients who had both CVCs and PVCs were excluded. Patients whose positive blood cultures were within 2 days of admission according to the NHSN definition of present on admission were excluded. Patients who did not have an eligible PVC line nor an eligible BSI organism (i.e., only 1 common commensal) according to the previously mentioned definitions were excluded.

Statistical Analysis

A case control comparison was designed using a 3:1 ratio of controls (n = 36) to cases (n = 12). A table of odds ratios and 95% confidence intervals was calculated for risk of extended dwell time and anatomical PVC locations including antecubital, wrist, forearm, and overall flexure. Analyses were conducted in R 4.1.3 using the Epidemiology Tools package, version 0.5-10.1.

Results

Case Characteristics

A total of 703 patients with bacteremia was identified during the study period: 480 community onset and 158 either secondary BSIs or with only 1 common skin commensal. Of the 65 hospital-onset bacteremias, 12 (1.7%) PVC-BSI cases were identified. The plurality of PVC-BSI cases was due to *Staphylococcus aureus* (5), 2 of which were methicillin resistant (Table 1). Of the CLABSI group, the plurality of cases was due to *Staphylococcus epidermidis* (5). Risk factors for PVC-BSI were investigated using a case control methodology (Table 2).

Table 1. Case Characteristics for PVC-BSIs and CLABSIs

Characteristics	PVC-BSI	CLABSI
Number of cases (non-ICU)	12 (12)	31 (15)
Infection rate per 1000 line days (non-ICU)	0.115 (0.115)[a]	0.588 (0.199)[b]
Median age, y	59.5	59
Male : female ratio	8:4	20:11
Median line days	**5.5**	8
Staphylococcus aureus cases (non-ICU)	5[c] (5)	2 (1)
Staphylococcus epidermidis cases (non-ICU)	0 (0)	5 (2)

CLABSI = central line-associated bloodstream infection; ICU = intensive care unit; PVC-BSI = peripheral venous catheter-associated bloodstream infection.
[a] $P < 0.0001$.
[b] $P = 0.015$.
[c] *Staphylococcus aureus* made up a greater percentage of PVC-BSIs than CLABSI ($P = 0.0123$).

The PVC-BSI rate was 0.115 per 1000 line days compared with 0.588 per 1000 line days for CLABSI (n = 31). All intensive care unit (ICU) patients had both PVCs and central lines. The rate of CLABSI per 1000 line days in the non-ICUs during the study period was 0.199 (n = 10). The rates of CLABSI house-wide were significantly higher than PVC-BSIs ($P < 0.001$). However, given that almost all patients with central lines also had PVCs, it would be reasonable to assume that the rate of CLABSIs and PVC-BSIs were statistically similar in

Table 2. Odds Ratios and 95% Confidence Intervals for PVC-BSIs

	Odds Ratio	95% Confidence Interval
PVC location		
Antecubital	0.35	0.065, 1.429
Wrist	1.62	0.048, 21.807
Overall flexure	0.57	0.134, 2.709
Forearm	1.42	0.345, 5.597
PVC dwell time		
Dwell time > 96 h	5.48 ($P = 0.02$)	1.335, 24.899

PVC = peripheral venous catheter.

non-ICU patients because some CLABSIs were likely due to the PVCs alone. Using a crude method of subtracting the rates of PVC-BSI from CLABSI, the rate of non-ICU CLABSI was 0.084 per 1000 line days, below that of PVC-BSIs.

Discussion

Using a case control design, we compared the risk of PVC-BSI to CLABSI. All patients with CLABSI also had a PVC at some point during their hospital encounter. It is possible that some BSIs were due to PVCs rather than central lines. If a central line was present, we excluded the PVC line days and BSIs. If only 20% of the CLABSI cases were attributable to the PVC and not the central line, a plausible assumption given the PVC-BSI rate, then most non-ICU vascular access-associated BSIs would be due to PVCs. Additionally, patients with PVC dwell times of greater than 96 hours were 5.48 times more likely to develop a PVC-BSI ($P = 0.02$). We suspect this is due to dressing disruption over time, which has been shown to be a major risk factor for catheter-related infections.[7] The average dwell time of PVCs replaced due to clinical indication compared with set time intervals in studies examining the risks of PVC complications is 3.5 days.[8] The average PVC dwell time in this study was 7.5 days. Therefore, further research is needed to examine the risk factors for PVC complications in dwell times exceeding 3.5 days.[8]

PVCs are likely an underrecognized source of *Staphylococcus aureus* BSIs.[9] These are associated with significantly worse outcomes than bacteremias due to *Staphylococcus epidermidis*. During the study period, most vascular access-associated BSIs due to *Staphylococcus aureus* were associated with PVCs. Of the 12 hospital onset methicillin-resistant *Staphylococcus aureus* bacteremia reported to the Centers for Medicare and Medicaid Services (CMS) during the study period, 4 were PVC related (2 PVC-BSI and 2 CLABSI with PVCs in place). Therefore, the high use of PVCs in health care combined with the severity of *Staphylococcus aureus* infections demands active surveillance.

Recently, the CMS suggested that they are considering focusing on hospital-onset bacteremias.[10] If this were to occur, institutions will be forced to look at all causes of bacteremia, including CLABSI, postoperative sepsis, and PVC-BSI. Our data suggest that PVC-BSIs would be identified as a significant source of infections, and therefore, national risk-adjusted baseline rates should be established now so that institutions can begin to assess their needs around PVC-BSI prevention.

This study has 3 limitations. Our institution used extended dwell times and chlorhexidine (CHG)-impregnated sponges on PVCs in place greater than 24 hours. The PVC brand used is physically shorter than other models, making placement of the CHG-impregnated sponge around the PVC suboptimal. Thus, our results may not be applicable to facilities with other practices. Lastly, the study timeline was limited to 9 months, resulting in a small number of cases.

In conclusion, PVC-BSIs were responsible for most vascular access-associated *Staphylococcus aureus* bacteremias. Developing an EMR-based PVC-BSI active surveillance program is achievable in most hospitals. Data obtained could be used for performance improvement and to implement best practices. Adopting the SHEA/IDSA/APIC Practice Recommendations[11] and Infusion Therapy Standards of Practice[5] could result in a significant reduction of hospital-onset bacteremias with highly pathogenic organisms.

Disclosure

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1. Author: Hyphens added and "compared to" changed to "compared with" in title. CEEditor: Unstructured abstract okay as set for practical use article? CE OK with change
2. Author: Please spell out SHEA/IDSA/APIC. CE
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SHEA: Society for Healthcare Epidemiology of America
IDSA: Infectious Diseases Society of America
APIC: Association for Professionals in Infection Control and Epidemiology

Query 3: February 10, 2022

Query 4: Please unbold the value. The value was not meant to be bolded.