Peripheral intravenous catheter-associated *Staphylococcus aureus* bacteraemia: more than 5 years of prospective data from two tertiary health services

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Abstract

Objectives: To determine the incidence, risk factors for and outcomes of *Staphylococcus aureus* bacteraemia (SAB) associated with peripheral intravenous catheters (PIVCs).

Design, setting and patients: A review of prospectively collected data from two tertiary health services on all health care-associated SAB episodes occurring in adults aged > 17 years from January 2007 to July 2012.

Main outcome measures: Numbers of health care-associated SAB episodes; device type, location of insertion, device dwell time and outcome at 7 and 30 days for all SAB episodes associated with use of a PIVC; rates of SAB per 10 000 occupied bed-days (OBDs).

Results: Overall, 137 of 583 health care-associated-SAB episodes (23.5%) were deemed to be PIVC associated, with an incidence of 0.26/10 000 OBD. The mean dwell time for PIVCs was 3.5 days (range, 0.25–9 days) and 45.2% of SABs occurred in PIVCs with a dwell time ⩾ 4 days. Of the PIVC-associated SAB episodes, 39.6% involved PIVCs inserted in the ED, 39.6% involved PIVCs inserted on wards and 20.8% involved PIVCs inserted by the ambulance service. Of the PIVC-associated SABs occurring within 4 days of insertion, 61% were inserted by ED staff or the ambulance service. PIVC-associated SAB were associated with a 30-day all-cause mortality rate of 26.5%.

Conclusion: PIVC-associated SAB is an under-recognised complication. The high incidences of SAB associated with PIVCs inserted in emergency locations and with prolonged dwell times support recommendations in clinical guidelines for routine removal of PIVCs.

Staphylococcus aureus bacteraemia (SAB) is an important hospital-acquired infection often associated with indwelling devices.[1-3] The risk of a peripheral intravenous catheter (PIVC) leading to SAB is low, estimated to occur in about 0.1% of lines.[4] However, up to 80% of hospitalised patients have a PIVC in situ at some time during their acute stay,[5,6] so absolute numbers of PIVC-associated SAB may be a more pressing issue than has been previously recognised.[1,3,5]

Debate over the need for routine PIVC replacement is ongoing. In 1996, the United States Centers for Disease Control and Prevention recommended that PIVC sites should be rotated at intervals of 48–72 hours.[7] Later guidelines suggested that routine PIVC changes were not required more frequently than 72–96 hours in adults.[8] In 1998, researchers reported that the hazard for PIVC complications (thrombophlebitis, infection) did not appear to increase during prolonged catheterisation and recommended that routine replacement was unnecessary.[9] These findings have been recently echoed in a multicentre randomised trial involving over 3200 patients but remain controversial.[10]

We sought to review 5 years of PIVC-associated SAB in two tertiary referral health services to define the frequency, mortality and associated risk factors for this health care-associated complication.

Methods

Two tertiary referral health services in Melbourne (Monash Health and Austin Health, with 2150 and 840 beds, respectively) were included in our analysis. Both services prospectively used the same data collection tool to collect data on every episode of SAB that occurred within each facility. The data for this study included all health care-associated SAB episodes occurring in adults aged > 17 years at each site from January 2007 to July 2012.

Every positive blood culture for *S. aureus* was investigated by infection control and classified as health care or community associated. Health care-associated SAB was defined as isolation of *S. aureus* from one or more blood cultures taken:

- during hospitalisation, 48 hours or more after admission; or
- within 48 hours of admission in a patient with an indwelling medical device; or
- within the last 30 days in a patient who has had surgery and the SAB is deemed to be related to the procedure; or
- within 48 hours of an invasive procedure.

Data collected for each health care-associated SAB episode included patient demographics, place of acquisition (community or hospital), likely source of infection, primary clinical manifestation and outcomes at 7 and 30 days. Neither service has a dedicated peripheral-line management team.

For SAB deemed to be device-related, details of device type, place of insertion (ambulance, emergency department [ED], ward) and device dwell time (days before the SAB was identified) were collected. A case of PIVC-associated SAB was defined as a health care-associated SAB in a patient:

- with a PIVC in situ or removed within the 7 days before the positive blood culture; and
- with no other source of SAB identified and either a physician or nurse documenting the PIVC as the source of the SAB in the medical record; and/or
- with physical findings suggesting a PIVC as the source (erythema, induration, phlebitis, tenderness).

To estimate the PIVC-associated SAB rate we used occupied bed-days (OBD) for all overnight stays as the denominator.

1 Sources of health care-associated *Staphylococcus aureus* bacteraemia (SAB) in two tertiary health services, January 2007 to July 2012

Source	SAB episodes, no. (%)		
	Monash Health	Austin Health	Total
Device-associated	267 (67.6%)	107 (56.9%)	374 (64.2%)
PIVC	96 (24.3%)	41 (21.8%)	137 (23.5%)
Central line	78 (19.7%)	24 (12.8%)	102 (17.5%)
PICC	47 (11.7%)	12 (6.4%)	59 (10.1%)
Haemodialysis	27 (6.8%)	15 (8.0%)	42 (7.2%)
Urinary device	9 (2.3%)	3 (1.6%)	12 (2%)
Orthopaedic device	3 (0.8%)	6 (3.2%)	9 (1.5%)
Other device	7 (1.8%)	6 (3.2%)	13 (2.2%)
Not device-associated	128 (32.4%)	81 (43.1%)	209 (35.9%)
Total	**395**	**188**	**583**

PIVC = peripheral intravenous catheter. PICC = peripherally inserted central catheter. ◆

This study was approved at both hospitals by their respective ethics committees as a quality study.

Results

There were 583 health care-associated SAB episodes across the two health services, with 137 (23.5%) deemed to be PIVC-associated SAB (Box 1). The total number of episodes of PIVC-associated SAB exceeded that of SAB associated with central intravenous lines (102 [17.5%]).

Over the period of the study there were 5 235 560 total OBDs across both sites and an overall rate of PIVC-associated SAB of 0.261/10 000 OBD (Box 2). Of the patients with PIVC-associated SAB, 95 (69%) were men and mean age was 71 years (range, 18–95 years).

Dwell time could be ascertained in 124 of the 137 episodes of PIVC-associated SAB. Of these, the mean PIVC dwell time was 3.5 days (median, 3 days; range, 0.25–9 days). Fifty-six PIVC-associated SAB episodes (45.2%) occurred in PIVCs with dwell times greater than or equal to 4 days (Box 2).

There were 44 PIVCs (39.6%) inserted in the ED, 44 (39.6%) in the ward and 23 (20.8%) by the ambulance service (Box 2). Of 68 PIVC-associated SAB episodes occurring within 3 days of insertion, 24 (35.3%) were inserted in the ED or by the ambulance service. This increased to 61% (48 of 79 SAB episodes) for dwell times of ⩽ 4 days.

PIVC-associated SAB episodes were associated with a 30-day all-cause mortality rate of 26.5%.

Discussion

Data collected over more than 5 years in two tertiary health services showed a high incidence of SAB episodes associated with PIVCs inserted in emergency locations and with prolonged (⩾ 4 days) dwell times.

SAB is a major cause of morbidity and mortality. Similar to our finding of 26.5%, a 30-day all-cause mortality rate of 20.6% has been reported previously in a study of 1994 episodes of SAB.[3]

Each PIVC-associated SAB episode also has a significant financial cost. Financial data for SAB in Australia are scarce, and measuring the economic costs were beyond the scope of this study. Assumed additional costs of $20 000 per episode have been previously quoted.[2] This would equate to $29 500 on average, adjusted for the consumer price index, and give an estimated total cost of PIVC-associated SAB at our two institutions for the study period of $4.04 million.

Reducing PIVC-associated SAB is therefore paramount. Prevention strategies include not inserting PIVCs unless needed, ensuring aseptic technique on insertion and early removal when the line is no longer required or when it is inserted during emergency situations. Additionally, reduction of SAB may also be possible by routine replacement of PIVCs.[7,8] A multicentre, randomised, non-blinded equivalence trial among adults with a PIVC of expected use longer than 4 days was reported recently. Researchers compared rates of thrombophlebitis, during catheterisation or within 48 hours of removal, between patients who had PIVCs routinely replaced on Day 3 and those having a PIVC replaced only if clinically indicated (completion of therapy, thrombophlebitis, inflammation, occlusion, suspected infection). While the study was powered for phlebitis, they only noted one PIVC-associated SAB (in the routine-change arm) in 3283 patients and out of 5907 catheters.[10]

Our study design was based on investigation of each incident case of SAB, not following two arms of a randomised cohort. We believe our data suggest that timely removal of PIVCs is important for reducing risk of SAB, particularly when inserted in suboptimal circumstances. The likely explanation for the different finding of the equivalence trial is that the true incidence of PIVC-associated SAB was below the level of detection allowed by its design, and that phlebitis is not a reliable predictor of SAB.

Other factors that might have influenced the results of the equivalence study include non-blinding of the research nurses, the daily presence of research nurses on the wards and up to 40% of PIVC being placed by a specialised team dedicated to inserting intravenous catheters.[10] Our study, on the other hand, shows rates of PIVC-associated SAB in a real-life situation, where PIVCs were inserted in EDs and wards.

2 Details of PIVC-associated *Staphylococcus aureus* bacteraemia in two tertiary health services, January 2007 to July 2012*

Variable	Monash Health	Austin Health	Total
Rate per 10 000 OBD	0.288	0.280	0.261
MRSA episodes	18/96 (18.8%)	14/41 (34.1%)	32/137 (23.4%)
Location where insertion took place			
Ambulance	20/77 (26.0%)	3/34 (8.8%)	23/111 (20.8%)
ED	28/77 (36.4%)	16/34 (47.1%)	44/111 (39.6%)
Ward	29/77 (37.7%)	15/34 (44.1%)	44/111 (39.6%)
Mean dwell time, days (range)	3.5 (1–9)	3.5 (0.25–9)	3.5 (0.25–9)
Dwell time ⩾ 4 days	43/90 (47.8%)	13/34 (38.2%)	56/124 (45.2%)
Alive at 7 days	89/96 (92.7%)	38/41 (92.7%)	127/137 (92.7%)
Alive at 30 days	48/61 (78.7%)	27/41 (65.9%)	75/102 (73.5%)

OBD = occupied bed-days. MRSA = methicillin-resistant *S. aureus*. ED = emergency department. * Values are no. of episodes/total PIVC-associated SAB episodes (%) unless otherwise indicated. Denominators vary according to the total number of episodes that could be ascertained for each variable. ◆

From our study, we cannot confirm whether PIVC replacement at 72–96 hours is appropriate or whether only clinically indicated replacement is warranted. However, about 45% of PIVC-associated SAB were potentially preventable by removal before the 4-day cut-off.

Strengths of our study include the large numbers of cases across two sites and the prospective nature of data collection. Limitations include the fact that the rate of PIVC-associated SAB we have defined is a crude rate. To adequately define relative risks associated with longer dwell times we would need data on PIVC days among this population. Additionally, although to our knowledge these data are the largest series of PIVC-associated SAB episodes reported, the results may not be generalisable to all health services.

Our study highlights the significant issue of PIVC-associated SAB. Further studies powered for the outcome of SAB to solve the issue of whether routine PIVC replacement reduces SAB are required, as are studies investigating the cost of SAB. In the meantime, protocols for PIVC removal at ⩽ 4 days will remain at our two hospitals. National standards for PIVC insertion and maintenance are needed.

Competing interests: No relevant disclosures.

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