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Six-year study on peripheral venous catheter–associated BSI rates in 262 ICUs in eight countries of South-East Asia: International Nosocomial Infection Control Consortium findings

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Abstract

Background: Short-term peripheral venous catheter–associated bloodstream infection rates have not been systematically studied in Asian countries, and data on peripheral venous catheter–associated bloodstream infections incidence by number of short-term peripheral venous catheter days are not available.

Methods: Prospective, surveillance study on peripheral venous catheter–associated bloodstream infections conducted from 1 September 2013 to 31 May 2019 in 262 intensive care units, members of the International Nosocomial Infection Control Consortium, from 78 hospitals in 32 cities of 8 countries in the South-East Asia Region: China, India, Malaysia, Mongolia, Nepal, Philippines, Thailand, and Vietnam. We applied US International Nosocomial Infection Control Consortium definition criteria and reported methods using the International Nosocomial Infection Control Consortium Surveillance Online System.

Results: We followed 83,295 intensive care unit patients for 369,371 bed-days and 376,492 peripheral venous catheter-days. We identified 999 peripheral venous catheter–associated bloodstream infections, amounting to a rate of 2.65/1000 peripheral venous catheter-days. Mortality in patients with peripheral venous catheter but without peripheral venous catheter–associated bloodstream infections was 4.53% and 12.21% in patients with peripheral venous catheter–associated bloodstream infections. The mean length of stay in patients with peripheral venous catheter but without peripheral venous catheter–associated bloodstream infections was 4.40 days and 7.11 days in patients with peripheral venous catheter and peripheral venous catheter–associated bloodstream infections. The microorganism profile showed 67.1% were Gram-negative bacteria: *Escherichia coli* (22.9%), *Klebsiella* spp (10.7%), *Pseudomonas aeruginosa* (5.3%), *Enterobacter* spp. (4.5%), and others (23.7%). The predominant Gram-positive bacteria were *Staphylococcus aureus* (11.4%).

Conclusions: Infection prevention programs must be implemented to reduce the incidence of peripheral venous catheter–associated bloodstream infections.

Keywords

Hospital infection, device-associated infections, antibiotic resistance, peripheral line–associated bloodstream infections, mortality, intensive care unit, surveillance

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Introduction

One of the most habitually performed invasive procedures in healthcare facilities worldwide is short-term peripheral venous catheter (PVC) therapy.[1–3] According to a recent systematic review, PVCs are widely used in industrialized countries, and around 200 millions of PVCs are inserted in US hospitals each year.[3] In different point-prevalence studies, PVCs accounted to 80%, 90%, and 95% of all intravascular devices placed in inpatients in France, in Scotland, and Spain, respectively.[3]

Such high prevalence of PVCs inserted regularly has been reported to result in considerable morbidity, excess length of stay (LOS) and hospital costs, prolonged antibiotics treatments, and bloodstream infections (BSIs).[4]

In addition, it was reported that the overall PVC failure rate ranges from 35% to 50%,[1,2,5] with such failures being responsible for causing PVC-associated adverse events, such as phlebitis, occlusion/mechanical failure, infiltration, dislodgment, and BSIs.[1,2,5–10]

In industrialized countries, the incidence of peripheral venous catheter–associated bloodstream infections (PVCA-BSIs) in patients admitted to intensive care units (ICUs) has been reported to be 0.5 per 1000 PVCs-days in ICUs from Australia, Italy, and the United States[11] and 0.67 PVCA-BSIs per 1000 PVCs-days in pediatric and neonatal ICUs from Australia.[12]

This study, which was conducted during 6 years, between 1 September 2013 and 31 May 2019, in 204 ICUs, in 78 hospitals from 32 cities of 8 countries (China, India, Malaysia, Mongolia, Nepal, Philippines, Thailand, and Vietnam), is the first comprehensive one to analyze the incidence rate, bacterial resistance, LOS, and mortality attributable to PVCA-BSI in countries of the South-East Asia Region.

Methods

Background on International Nosocomial Infection Control Consortium

International Nosocomial Infection Control Consortium (INICC) comprised of a group of hospitals, in 210 cities, in 54 countries in six World Health Organization (WHO) regions: Africa, the Americas, Eastern Mediterranean, Europe, South-East Asia, and Western Pacific.

INICC is the largest source of aggregate standardized international data on the epidemiology of healthcare-associated infections worldwide.[7,13]

Study design

This prospective, cohort surveillance study was conducted through an online platform called INICC Surveillance Online System (ISOS). Through ISOS, validation of each PVCA-BSI was checked by infection control professionals (ICPs) and the recorded signs of infection and the results of cultures, laboratory, and studies were scrutinized to assure that Centers for Disease Control and Prevention (CDC)/ National Healthcare Safety Network (NHSN) criteria for PVCA-BSIs were met.[13,14]

INICC methods

The ISOS includes the implementation of CDC/NHSN's methodology, but adds other data to increase ICPs' sensitivity to detect PVCA-BSIs and avoid underreporting.[13]

Outcome surveillance data collection and validation

This study presents the results of Outcome Surveillance of PVCA-BSIs in the ICU which follows the INICC protocol and allows the classification of prospective, active, cohort data into specific module protocols.

All patients with usage of a central line were excluded from this study. Only patients with PVC were included in this study.

ICPs collected daily data on PVCA-BSIs and denominator data, such as specific device-days in the ICUs, patient-days, microorganism profile, and bacterial resistance.

Each PVCA-BSI reported by an ICP was validated; that is, scrutinized to be certain that all criteria were satisfied to justify its recording as a PVCA-BSI.[13]

Training

The INICC team trained and provided ICPs with manuals, training tools, and tutorial movies and evaluated on a routine basis that ICPs perform surveillance correctly through the ISOS online platform.

Definitions

BSI. We used US CDC/NHSN's definitions for BSI event (central line and non-central line–associated BSI) from its publication in 2013 and their amendments until its latest publication in 2019: "A patient of any age has a recognized pathogen cultured from one or more blood cultures and organism cultured from blood that is not related to an infection at another site."[15–18]

PVCA-BSI. US CDC/NHSN's definitions do not include the surveillance definition of PVCA-BSI.[15–18] We applied the CDC/NHSN's definition for patients that met all the criteria for BSI, but never used central lines, nor peripherally inserted central catheters. "PVC" includes the following devices: "short peripheral cannulas" (<6 cm), "long peripheral cannulas" (6–12 cm long, sometimes defined as "short-midlines") and "midline catheters" (15–25 cm long). In this study, we have considered only short cannulas (<6 cm) before the acquisition of a BSI.

Calculation

Data uploaded to ISOS were used to calculate PVCA-BSI rates per 1000 device-days, mortality, and LOS, according to the following formulas: device-days consisted of the total number of PVC-days.

Crude excess mortality of PVCA-BSI equaled crude mortality of ICU patients with PVCA-BSI minus crude mortality of patients without PVCA-BSI.

Crude excess LOS of PVCA-BSI equaled crude LOS of ICU patients with PVCA-BSI minus crude LOS of patients without PVCA-BSI.

Device utilization ratio (DUR) equaled the total number of peripheral venous catheter–related (PVCR)-days divided by the total number of bed days.

To calculate extra LOS and extra mortality, all central line–associated BSIs were excluded, and only patients with PVCs, both with or without BSIs, were included.

Follow-up of patients

To estimate PVCA-BSI rate and excess mortality attributable to PVCA-BSI, all patients were followed over 15 days, after step-down from the ICU.

Statistical analysis

ISOS version 2.0 (Buenos Aires, Argentina) was used to calculate PVCA-BSI rates, DURs, LOS, and mortality. EpiInfo® version 6.04b (CDC, Atlanta, GA) and SPSS 16.0 (SPSS Inc., an IBM company, Chicago, IL) were also used; 95% confidence intervals (CIs) and p values were determined for all outcomes.

Setting

The study was conducted in 727 ICUs from 268 hospitals in 141 cities of 8 countries in the South-East Asia Region (China, India, Malaysia, Mongolia, Nepal, Philippines, Thailand, and Vietnam), through the implementation of the ISOS, as described above.

All the cohort of patients admitted to the ICUs during the study period was enrolled in the study with hospitals' Research Ethics Committees approval.

In accordance with the INICC protocol, hospitals' identities are kept under confidentiality and patient data were anonymized.[13]

Table 1. Type of ICU and hospitals' ownership.

ICUs, type	No. of ICUs	%
Burn	2	0.76
Cardiothoracic	12	4.58
Coronary	21	8.02
Medical	50	19.08
Medical/surgical	86	32.82
Neurosurgical	21	8.02
Neurologic	10	3.82
Pediatric	15	1.91
Respiratory	5	10.69
Surgical	28	2.29
Trauma	6	2.67
Other	7	5.34
Total	262	100
Hospitals		
Academic teaching, n, %	8	10.25
Public, n, %	5	6.41
Private community, n, %	65	83.33
Total hospitals, n, %	78	100

ICU: intensive care unit.

Results

During the study period of 6 years, from 1 September 2013 to 31 May 2019, the mean length of participation of the ICUs was 21 months (standard deviation (SD): 26.2 months), ranges from 2 to 147 months.

Table 1 shows type of ICUs and type of hospitals' ownership. The predominant types of ICU were medical/surgical (32.82%), medical (19.08%), and surgical (10.69%). Private community hospitals amounted to 83.33%.

Table 2 shows PVCA-BSI rates and DURs by type of ICU. The pooled mean rate was 2.65 PVCA-BSIs per 1000 PVC-days. The pooled DUR mean was 1.04 (1.03–1.04, 95% CIs; 0.63 SD).

Table 3 provides data on crude ICU mortality and crude LOS in patients with and without PVCA-BSI. The pooled mean of crude mortality was 12.21% in patients infected with PVCA-BSIs and 4.53% in patients with PVC that were not infected. The excess LOS of patients with PVCA-BSI was 62% higher than in patients without PVCA-BSI.

Table 2. Pooled means, 95% confidence intervals of the distribution of short-term peripheral venous catheter–associated bloodstream infections rates by type of location, in adult and pediatric intensive care units.

Type of ICU	ICU, n	Patients, n	PVCA-BSIs, n	Bed days	PVC days, n	Pooled PVCA-BSI rate	Device utilization ratio			
							Mean	95% CI		SD
Burn	2	184	14	2316	2108	6.64	0.99	0.96	1.01	0.15
Cardiothoracic	12	534	1	1958	2259	0.44	1.06	0.98	1.15	1.01
Coronary	21	2818	19	9864	10,343	1.84	1.07	1.04	1.09	0.57
Medical	50	15,954	88	78,145	75,710	1.16	0.97	0.96	0.97	0.52
Medical/surgical	86	47,743	777	201,654	207,933	3.74	1.04	1.04	1.05	0.66
Neurosurgical	21	3446	6	15,799	15,418	0.39	1.01	0.98	1.04	0.96
Neurologic	10	751	14	3203	3445	4.06	1.08	1.06	1.10	0.29
Pediatric	15	4240	55	20,173	24,447	2.25	1.28	1.27	1.30	0.60
Respiratory	5	10	0	44	38	0.00	0.97	0.63	1.31	0.47
Surgical	28	5162	16	27,103	25,889	0.62	0.98	0.97	0.99	0.53
Trauma	6	2179	6	8069	7872	0.76	0.98	0.97	0.99	0.33
Other	7	273	3	1043	1030	2.91	0.99	0.97	1.02	0.23
Pooled (adult and pediatric ICUs)	262	83,294	999	369,371	376,492	2.65	1.04	1.03	1.04	0.63

ICU: intensive care unit; PVCA-BSI: short-term peripheral venous catheter–associated bloodstream infections; PVC: short-term peripheral venous catheter; CI: confidence interval; SD: standard deviation.

Table 3. Pooled means of the distribution of crude mortality and length of stay of intensive care unit patients with short-term peripheral venous catheter–associated bloodstream infections in adult and pediatric intensive care units combined.

	No. of deaths	No. of patients	Pooled crude mortality, % (mean; standard deviation; 95% CI)	LOS, total days	Pooled mean LOS, days (standard deviation; 95% CI)
Adult and pediatric patients, without PVCA-BSI	3731	82,295	4.53% (0.05; 0.21; 0.04–0.05)	362,269	4.40 (4.39; −4.41)
Adult and pediatric patients, with PVCA-BSI	122	999	12.21% (0.12; 0.33; 0.11–0.13)	7102	7.11 (8.11; 7.08–7.14)
Total	3853	83,295	–	369,371	–

CI: confidence interval; LOS: length of stay; PVCA-BSI: short-term peripheral venous catheter–associated bloodstream infections.

Table 4. Antimicrobial resistance rates in intensive care units.

Pathogen, antimicrobial	PVCA-BSI	
	No. of pathogenic isolated tested at INICC ICUs, pooled (n)	*Resistance percentage, % (n)*
Pseudomonas aeruginosa		
FQs	12	25.00 (3)
PIP or TZP	12	25.00 (3)
AMK	13	30.77 (4)
IPM or MEM	11	36.36 (4)
Klebsiella pneumoniae		
CRO or CAZ	16	81.25 (13)
IPM, MEM, or ETP	32	53.13 (17)
Acinetobacter baumanii		
IPM or MEM	7	71.42 (5)
FQs	8	87.5 (7)
Escherichia coli		
CRO or CAZ	47	63.82 (30)
IPM, MEM, or ETP	73	9.59 (7)
FQs	66	57.58 (38)
Staphylococcus aureus		
OXA	22	59.09 (13)
Enterococcus faecalis		
VAN	2	0.0 (0)

INICC: International Nosocomial Infection Control Consortium; ICU: intensive care unit; PVC: short-term peripheral venous catheter; PVCA-BSI: PVC-associated bloodstream infections; FQs: fluoroquinolones (ciprofloxacin, levofloxacin, moxifloxacin, or ofloxacin); PIP: piperacillin; TZP: piperacillin-tazobactam; AMK: amikacin; IPM: imipenem; MEM: meropenem; CRO: ceftriaxone; CAZ: ceftazidime; ETP: ertapenem; OXA: oxacillin; VAN: vancomycin.

Table 4 provides data on bacterial resistance of pathogens isolated from patients with PVCA-BSI in adult and pediatric ICUs. Resistance of *Pseudomonas aeruginosa* to imipenem (IPM) or meropenem (MEM) was 36.36%, of *Acinetobacter baumanii* to IPM or MEM was 71.42% and to fluoroquinolones was 87.5%, and of *Klebsiella pneumoniae* to ceftriaxone or ceftazidime was 81.25%. Regarding Gram-positive bacteria, *Staphylococcus aureus*'s resistance to oxacillin was 59.09% and *Enterococcus faecalis* was 100% sensitive to vancomycin.

Figure 1 shows microorganism profile of PVCA-BSIs. There was a predominance of Gram-negative bacteria (67.1%) with *Escherichia coli* (22.9%) and *K. pneumoniae* (10.7%). The predominant Gram-positive bacteria found were *S. aureus* (11.4%) and Coagulase-negative *Staphylococci* spp (8.2%).

Discussion

To date, there are no previous representative studies of PVCA-BSI rates conducted in countries from the South-East Asia Region, nor in most resource-limited countries worldwide from the six WHO regions.

This comprehensive study with 83,295 patients is unprecedented in this region in terms of both the data presented and the analyses conducted to calculate PVCA-BSI rates per 1000 device-days.[6] The mean rate found in our study was 2.65 PVCA-BSIs per 1000 PVC-days. So far, the incidence of PVCA-BSI has been published by 1000 PVC-days in only two studies from industrialized countries so far: in a systematic review with data from only three industrialized countries (the United States, Australia, and Italy) published in 2006, with a PVCA-BSI rate of 0.5 per 1000 PVC-days,[11] and in a recent study conducted in Australia, with a rate of 0.67 PVCA-BSI per 1000 PVC-days.[12]

In a recently published systematic review by the Alliance for Vascular Access Teaching and Research (AVATAR) group, PVC-days were not reported as denominators of PVCA-BSIs rates. Therefore, this published data cannot be benchmarked against our data.[19] In the cited review, studies reported PVCA-BSI rates as follows:[19] Australia (0.39 PVCA-BSI per 10,000 occupied-bed days);[20] Germany (3.04 PVCA-BSI per 1000 patient-days);[21] Spain (1.17 PIVC-BSI per 10,000 patient-days,[22] and 0.05 PIVC/1000 patient-days);[23] and the United States (0.0150 PVCA-BSI per 100 patient-days[24] and 0.57 PIVCR-BSI per 1000 patient-days).[25]

In 2016, INICC published data of central-line-associated BSI (CLABSI) in 50 countries, prospectively collected from 2010 to 2015, from 861,284 ICU patients for 3,506,562 bed-days. Pooled rates for adult and pediatric ICUs were 4.1 CLABSIs per 1000 central line-days.[7] The comparison of INICC these data published in 2016 of CLABSI with this study's INICC present data on PVCA-BSI shows the pooled rate of CLABSI is 70% higher than the PVCA-BSI rate. However, since around 80%–90% of the vascular catheters used worldwide are PVCs, the raw number of BSIs due to PVC is around six times higher than due to CL.[26]

In our ICUs, the pooled mean of the distribution of crude mortality amounted to 12.21% of PVCA-BSIs cases, compared with 4.53% mortality of patients with PVC that were not infected. In recent studies from Spain and Japan, mortality attributable to PVCA-BSI was 13.2% and 12.9%, respectively.[22,27]

The excess LOS of patients with PVCA-BSI in our study was 62% higher than in patients without PVCA-BSI; in the previously cited study from Japan, patients who had acquired PVCA-BSI required a longer duration of antibiotic treatment (33.5 vs 15.8 days; $p = 0.004$) than patients without PVCA-BSI.[27]

Regarding the microorganism profile of PVCA-BSI, in our ICUs, there was a predominance of Gram-negative bacteria (67.1%): *E. coli* (22.9%), *K. pneumoniae* (10.7%), and others. Within the 29.3% of Gram-positive bacteria found, the predominant were *S. aureus* (11.4%) and Coagulase-negative *Staphylococci* spp (8.2%). This contrasts with findings from industrialized countries, in which Gram-positive pathogens were the predominant cause of PVCA-BSI.[28]

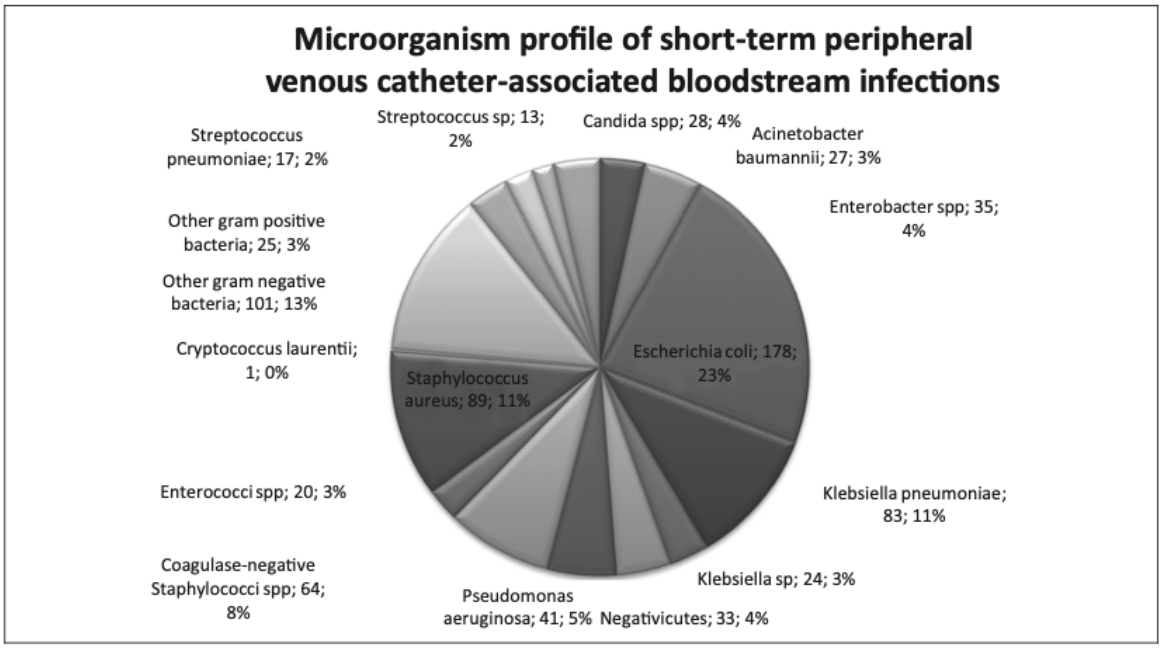

Figure 1. Microorganism profile of short-term peripheral venous catheter–associated bloodstream infections
*Other Gram-negative bacteria: It includes the following microorganisms that individually accounted for <1%: *Achromobacter* spp, *Achromobacter xylosoxidans*, *Acinetobacter lwoffii*, *Acinetobacter* sp, *Pseudomonas* sp, *Salmonella* spp, *Serratia marcescens*, and *Zymophilus*.
**Other Gram-positive bacteria: It includes the following microorganisms that individually accounted for <1%: *Aerococcus* spp, *Corynebacterium* sp, *Listeria monocytogenes*, *Methicillin-resistant Staphylococcus aureus, Micrococcus* spp, *Rothia* sp, and *Streptococcus mitis*.
***Other: It includes fungi that accounted for <1%: *Cryptococcus laurentii*.

Resistance of *P. aeruginosa* to fluoroquinolones, piperacillin, piperacillin-tazobactam, and amikacin was 25% and to IPM or MEM was 36.36%; of *A. baumanii* to IPM or MEM was 71.42% and to fluoroquinolones was 87.5%; and of *K. pneumoniae* to ceftriaxone or ceftazidime was 81.25% and to IPM or MEM or ertapenem was 53.13%.

Regarding Gram-positive bacteria, resistance of *S. aureus* to oxacillin in 59.09% of cases and *E. faecalis* was 100% sensitive to vancomycin, similar to the findings of a study from India.[29]

Study limitations

The purpose of this report is to obtain updated data on PVCA-BSI, device utilization, bacterial resistance, LOS, and mortality of patients with and without PVCA-BSI, but it does not provide insights regarding the impact of INICC interventions.[13,30] Second, most PVCs were inserted inside the ICU, which may have affected the BSI rate. Third, we did not collect the type of cannulas used (polyurethane or Teflon), the site of insertion (upper limb, lower limb, external jugular), the modality of antisepsis, and the type of dressing. Finally, benchmarking with CDC/NHSN was not possible because PVCA-BSI rates are not reported nor determined by PVC-days.[31,32]

Conclusion

This study presents the only available comprehensive data from eight countries of the South-East Asia Region showing PVCA-BSIs per 1000 PVC-days, which were much higher than the data available from industrialized countries. PVCA-BSI prevention programs should be implemented in healthcare facilities in this Region to reduce PVCA-BSI rates.

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Author contributions

All authors were involved in drafting of the manuscript, provision of study patients, collection of data, critical revision of the manuscript for important intellectual content, and final approval of the manuscript. V.D.R. was responsible for study conception and design; software development; data assembly, analysis, and

interpretation; epidemiologic analysis; statistical analysis; and administrative, technical, and logistical support.

Declaration of conflicting interests

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Appendix I

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