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Short report

Results of a multi-faceted educational intervention to prevent peripheral venous catheter-associated bloodstream infections

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SUMMARY

Peripheral venous catheter-associated bloodstream infections (PVC-BSIs) lead to prolonged hospitalization, morbidity and increased costs. The impact of infection-prevention measures on the rate of PVC-BSIs in a university hospital in Spain was assessed. An active surveillance programme was initiated in 2015, which revealed a high PVC-BSI incidence ratio (0.48/1000 patient-days). A bundle aimed at nurses, medical staff and patients was implemented, and a Catheter Infection Team (CIT) was set up. The intervention achieved a decrease in PVC-BSI rate: 0.34 in 2016, 0.29 in 2017, and 0.17 in 2018. The decline was greatest for Gram-negative PVC-BSIs (67.6% in 2015, 35.3% in 2018).

Introduction

Traditionally, little attention has been paid to peripheral venous catheter-associated bloodstream infections (PVC-BSIs), but there has recently been a rising interest in this topic [1]. A meta-analysis in 2006 evaluating BSI risk with different intravascular devices (IVDs) found that rates of IVD-related BSIs were lowest with PVCs (0.1%, 0.5 per 1000 IVD days) [2]. Although there are no epidemiological data in Europe on PVC use in hospitals, national surveys suggest that there is a high variability between countries. In Spain, more than 70% of hospitalized patients have a PVC [3]. Moreover, a study conducted in this country showed that rates of PVC-BSIs and central venous

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catheter (CVC)-BSIs were similar [4]. Data from the VINCat Programme, an institutional surveillance programme for hospital-acquired infections in place in Catalonia (Spain), has estimated a PVC-BSI rate of 0.5/1000 patient-days [5]. Few studies assessing the impact of clinical intervention strategies have reported a sustained reduction in PVC-BSIs [6,7].

In August 2015, an active surveillance programme for catheter-associated BSIs was initiated in Son Llàtzer Hospital in Palma de Mallorca (Spain) and a high rate of PVC-BSIs was recorded. As a result, a multi-faceted preventive strategy was progressively introduced to reduce PVC-BSI rate. The aim of this study was to examine the results obtained with bundles implemented over a three-year period.

Methods

The impact of a multi-faceted programme for reducing the risk of PVC-BSIs in a single centre, Son Llàtzer Hospital, a 380-bed university hospital in Palma de Mallorca (Spain), is described.

During the study period, all catheter-associated BSIs were recorded and the following data collected: age, sex, Charlson comorbidity index (CI), ward and hospitalization area, catheter type, indwelling time, microbiological data, and outcome.

The programme, which was implemented in three phases, included a PVC-Infection Prevention Bundle consisting of: (1) promoting hand hygiene (HH) before the procedure; (2) replacing the previously used 0.5% chlorhexidine preparation with an alcohol-based 2% chlorhexidine preparation for skin antisepsis (Bohmclorh™ Chlorhexidine 2%); (3) selecting the appropriate catheter; (4) scrubbing the access port with an antiseptic and accessing the port only with sterile devices; (5) inspecting at every shift the catheter insertion site through the transparent dressing (Tegaderm™ IV); (6) removing 'idle' catheters and assessing daily the need for intravenous treatment.

First, during an observational period (August–December 2015), a nosocomial bacteraemia surveillance programme was implemented. A multi-disciplinary Catheter Infection Team (CIT) was set up, initially made up of two nurses, a microbiologist, an intensive care specialist, and two internal medicine specialists, all of them with a special interest in PVC-BSI.

Second, from January to December 2016, the bundle implementation required updating hospital policies on PVC insertion and maintenance following the Center for Disease Control and Prevention Guidelines [8] and initiating an extensive educational programme for nurses, nurse assistants, consultants and registrars. Small group sessions were held during which data on PVC-BSI rates were presented, HH was promoted, and the staff were reminded to remove catheters when no longer needed, when patients showed signs of phlebitis, or in case of malfunction. Nurses and nurse assistants were also advised to acquire certain habits, such as scrubbing the access port with an antiseptic and accessing the port only with sterile devices. Similarly, they were encouraged to inspect the catheter insertion site through the transparent dressing and to record the procedures and findings at every nursing shift. During the sessions with consultants and registrars, these were further reminded that a midline catheter or a peripherally inserted central catheter (PICC) should be used instead of a short peripheral catheter when the duration of intravenous therapy was likely to exceed six days or if the infusion solution was not compatible with a peripheral catheter, in accordance with the Michigan Appropriateness Guide for Intravenous Catheters (MAGIC) [9]. Furthermore, removal of 'idle' catheters and daily assessment of the need for intravenous treatment were recommended.

Third, from January 2017, part-time nurses from the CIT performed an observational audit of PVC insertion and maintenance practices and provided case-by-case counselling on PVC management. When appropriate, they also recommended using a different type of catheter or removing unnecessary catheters. Midline catheters were introduced in our hospital and their insertion was performed by the CIT nurses. PICC insertions were performed in the Anaesthetics Unit. An e-learning module on catheter insertion and maintenance was offered to all healthcare workers. Information regarding peripheral catheter care was transmitted on the hospital's TV channel and patients were encouraged to report any changes at their catheter insertion site or any new discomfort. In January 2018, alcohol-based solutions (Sterillium™ Gel (85% ethanol)) were made available at the point of care by placing wall-mounted dispensers beside each bed in every hospital room, in addition to the individual pocket-sized bottles that were already available.

Definitions

PVC-BSI was considered when clinical symptoms such as fever, hypotension, and phlebitis appeared in association with one positive blood culture for a recognized pathogen or with two consecutive positive blood cultures for common skin micro-organisms, such as coagulase-negative staphylococci, and a different source of bacteraemia was carefully excluded. A catheter tip culture was considered, but not required, to confirm PVC-BSI.

Presence of phlebitis was defined as an inflammation of the vein wall related to the PVC, with associated symptoms such as pain, erythema, swelling, induration, palpable venous cord, or purulent discharge at the insertion site.

Mortality was considered when it occurred due to any cause within 30 days of the onset of PVC-BSI, and related mortality was considered when no other explanation for this outcome was found by the investigators after an extensive review of the medical record.

Identification and antibiotic susceptibility testing of micro-organisms recovered from blood were performed using the automated Bactec FX (Becton Dickinson), matrix-assisted laser desorption ionization time-of-flight (MALDI-TOF) Mass Spectrometry, and MicroScan Walkaway 96 Plus (Beckman Coulter).

Statistical analysis

Values are reported as mean $\pm$ standard deviation (SD) or median and range for continuous variables, and as frequencies for categorical variables. All statistical analyses were performed using the IBM SPSS statistics software v23.0. PVC-BSI index rate (IR) was defined as the number of PVC-BSI episodes/1000 patient-days.

Ethical considerations

The study was approved by the Clinical Research Committee of Son Llàtzer University Hospital (Palma de Mallorca, Spain).

Results

During the study period, 544 nosocomial bloodstream infections were identified, of which 90 (16.5 %) were CVC-BSIs, and 101 (18.6 %) were PVC-BSIs. Patients with PVC-BSIs had a median age of 69.7 years (16–99), 34 (33.7%) were women, and the median Charlson CI was 5.0 (0–14). Eighty-nine (88.1%) episodes occurred in medical wards and 12 (11.9%) in surgical wards. PVCs had been inserted in the emergency department in 66 (65.3%) cases and median indwelling time was four days (p25–75:3.0–6.0). Microbiological data are presented in Table I. Gram-negative rods were frequently isolated and seven out of 101 episodes were polymicrobial. PVC-BSI-related infectious endocarditis was diagnosed in five cases and septic thrombophlebitis in one. Nine patients died, with five (5.3%) deaths related to PVC-BSIs, all of them with *Staphylococcus aureus* bacteraemia.

The quarterly distribution of episodes is shown in Figure 1. Monthly PVC-BSI rate was 4.00 episodes/month during the observational period, from August to December 2015, 2.75 in 2016, 2.50 in 2017, and 1.4 episodes/month in 2018. The observed improvement was primarily due to the decline in Gram-negative PVC-BSIs (Figure 1). Twenty PVC-BSIs were recorded during the first five-month observational phase in 2015 (PVC-BSI IR: 0.48). During the following years, a progressive decrease was observed: 33 PVC-BSIs were recorded in 2016 (PVC-BSI IR: 0.31), 30 in 2017 (IR: 0.29), and 18 in 2018 (IR: 0.17).

A decrease in other nosocomial BSI IRs, notably CVC BSIs and primary BSIs, was observed: in 2015, IR was 0.4 episodes/1000 patient-days for CVC-BSIs and 0.43 for primary BSIs; in 2018, IR was 0.08/1000 patient-days for CVC-BSIs and 0.18/1000 patient-days for primary BSIs.

The consumption rate of alcohol-based solutions for HH in the hospitalization area (excluding the Intensive Care Unit

Table I
Microbiological data

	Aug–Dec 2015	Jan–Dec 2016	Jan–Dec 2017	Jan–Dec 2018	Total study period
PVC-BSI number/micro-biological isolates	20/22	34/36	30/32	17/17	101/108
Gram-positive micro-organisms (%)	8 (33.3%)	15 (41.6%)	12 (37.5%)	11 (64.7%)	46 (42.6%)
Staphylococcus aureus					
MSSA	6	8	9	6	29
MRSA	1	2	0	2	5
Staphylococcus epidermidis	1	2	2	2	7
Other coagulase-negative staphylococci	0	1	1	2	4
Enterococcus spp.	0	1	0	0	1
Streptococcus mitis	0	1	0	0	1
Gram-negative micro-organisms (%)	14 (67.6%)	21 (58.3%)	20 (62.5%)	6 (35.3%)	62 (57.4%)
E. coli (ESBL)	5	9 (2)	6	1(1)	21 (3)
Klebsiella spp. (ESBL)	2	5 (1)	6	2(1)	15 (2)
Pseudomonas spp.	2	3	1	0	6
Enterobacter cloacae	2	0	4	0	6
Proteus spp.	1	0	1	1	3
Other Gram-negative species	2	4	2	2	11

ESBL, extended-spectrum beta-lactamase-producing bacteria; MRSA, meticilin-resistant *S. aureus*; MSSA, meticilin-sensitive *S. aureus;* MRSA, meticilin-resistant *Staphylococcus aureus*.

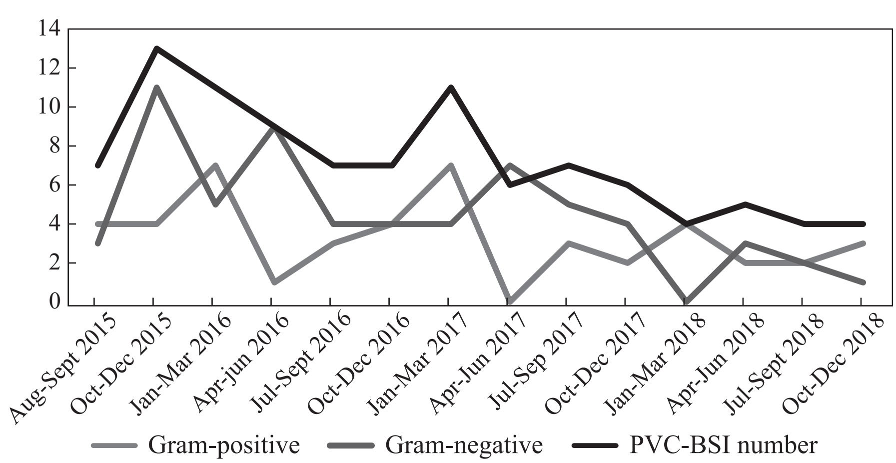

Figure 1. Quarterly distribution of total PVC-BSI, gram-positive and gram-negative PVC-BSI episodes during the study period.

(ICU)) increased from 13.5 L/1000 patient-days in 2016 to 22.9 L/1000 patient-days in 2018.

Discussion

The PVC-BSI surveillance programme identified an important, preventable, and previously ignored source of nosocomial infections in our hospital. The IR of PVC-BSIs was higher than that of CVC-BSIs. Moreover, PVC-BSIs were diagnosed among older patients with serious underlying diseases hospitalized in medical wards, and morbidity and mortality were high. Surprisingly, Gram-negative micro-organisms were frequently isolated. The programme achieved a significant reduction in PVC-BSI IR accompanied by a simultaneous decrease in CVC and primary BSI IR.

Previous studies and a meta-analysis showed the rate of PVC-BSIs was lower than the rate of CVC-BSIs [1,2] and, consequently, much more attention has been paid to CVC-BSI surveillance and prevention, especially in the ICU setting. In 2007, a publication of a study conducted in a single Spanish centre was the first to reveal that PVC-BSIs were at least as common as CVC-BSIs [4]. Since then, a small number of reports and studies have been published highlighting the significance of the morbidity and mortality associated with this hidden problem [1].

In our hospital, a multi-disciplinary CIT was established made up of nurses, medical staff, and a microbiologist with a special interest in PVC-BSIs, and an educational programme aimed at all the hospital's healthcare workers was developed. All the caregivers were involved in the programme. Training programmes, audits, and sessions on PVC insertion and maintenance practices for nurses have previously demonstrated their effectiveness, and studies conducted in France and Spain have shown significant reductions in PVC-BSI rates resulting from these interventions [6,7]. It was decided to involve bedside nurses, medical staff and, to a lesser extent, patients in PVC-BSI prevention. Prescribing doctors were encouraged to consider oral therapy before resorting to IV agents and to remove unnecessary catheters, and also to consider using a midline catheter or a PICC instead of a short peripheral catheter, when indicated, based on the MAGIC guidelines. The use of unnecessary or 'idle' PVCs has been described since 1992, when it was found that catheters were idle for two or more consecutive days in 35% of all IV catheter episodes in a Veterans Affairs Medical Centre, and quality improvement interventions led by internal medicine house staff have demonstrated a successful reduction in this proportion [10].

Unlike previous studies [4,7] in which Gram-positive bacteria and especially *S. aureus* were the most frequently isolated micro-organisms, Gram-negative PVC-BSIs accounted for the most common type of infections in our hospital, suggesting suboptimal HH. Furthermore, the observed progressive decline in *Enterobacteriaceae* as causative micro-organisms may be related to an improvement of this situation: HH was intensively promoted by the CIT at every opportunity and alcohol-based-solution dispensers were placed next to every patient's bed. A 1.7-fold increase in consumption rate was observed between 2016 and 2018.

A participatory role of patients in preventing hospital-acquired infections was promoted by the use of the hospital TV channel encouraging patients to notify staff of any discomfort, erythema, or oedema at the catheter insertion site. Unfortunately, an *ad hoc* questionnaire was not developed to evaluate the impact of this intervention on the reduction of phlebitis or PVC-BSIs.

Our study has limitations that should be considered. First, it was conducted at a single centre with a very high PVC-BSI incidence caused by Gram-negative micro-organisms, and the impact of the intervention described could differ in other hospitals. Second, data on phlebitis events were collected from medical records and could not be confirmed by the study nurses. Coagulase-negative staphylococcus PVC-BSIs may have been misclassified as primary BSIs if phlebitis was not reported, but a significant decrease in primary health-care BSIs was observed during the study period. Third, relevant information regarding catheter indwelling time and idle PVCs was not available. Finally, it was not possible to evaluate the impact of each action individually, and data on HH compliance are lacking.

In conclusion, our study identified PVC-BSIs as an important source of healthcare-associated bacteraemia and highlights the need to develop a national PVC-BSI register that could be part of National Healthcare System surveillance programmes. An affordable bundle, which included setting up a CIT and providing educational sessions for nurses and medical staff, led to a significant decrease in PVC-BSI IR.

Conflict of interest statement
None declared.

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