Impact of An Interventional Bundle on Complications Associated with Peripheral Venous Catheters in Children Admitted to A Cardiology Department

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1 author:

María Guembe
Hospital General Universitario Gregorio Marañón-Instituto de Investigación Sanitaria Gregorio Marañón

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ORIGINAL ARTICLE

Impact of an interventional bundle on complications associated with peripheral venous catheters in elderly patients

María Jesús Pérez-Granda[1,2,3] · Álvaro Irigoyen-von-Sierakowski[1] · Neera Toledo[4] · Eva Rodríguez[5] · María Luisa Cruz[5] · Giovanna Hernanz[5] · José Antonio Serra[5,6,7,8] · Martha Kestler[1] · Patricia Muñoz[1,3,6,8] · María Guembe[1,6]

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Abstract

Purpose Elderly patients admitted to geriatrics departments often require peripheral venous catheters (PVC), which should be inserted and maintained following a series of preventive recommendations. Our objective was to evaluate the impact of a training bundle comprising measures aimed at reducing complications associated with the use of PVC in elderly patients admitted to a tertiary teaching hospital.

Methods We performed a prospective study of patients who received a PVC within 24 h of admission to a geriatrics department. After a 10-month pre-interventional period, we implemented an educational and interventional bundle over a 9-month period. Follow-up was until catheter withdrawal. We analyzed and compared clinical and microbiological data between both study periods.

Results A total of 344 patients (475 PVC) were included (pre-intervention period, 204 patients (285 PVC); post-intervention period, 140 patients (190 PVC)). No statistically significant differences in demographic characteristics were observed between the study periods. The colonization and phlebitis rates per 1000 admissions in both periods were, respectively, 36.7 vs. 24.3 ($p = 0.198$) and 81.5 vs. 65.1 ($p = 0.457$). The main reason for catheter withdrawal was obstruction/malfunctioning (33.3%). Obstruction rate was higher for those inserted in the hand than for those inserted at other sites (55.7% vs. 44.3%, $p = 0.045$).

Conclusions We found no statistically significant differences regarding phlebitis and catheter tip colonization rates. It is necessary to carry out randomized studies assessing the most cost-effective measure to reduce complications associated with PVC.

Keywords Peripheral venous catheter · Elderly patients · Infection · Phlebitis · Complications · Bundle

✉ Patricia Muñoz
pmunoz@hggm.es

✉ María Guembe
maria.guembe@iisgm.com

1 Department of Clinical Microbiology and Infectious Diseases, Hospital General Universitario Gregorio Marañón, Dr. Esquerdo, 46, 28007 Madrid, Spain

2 Department of Nursing, School of Nursing, Physiotherapy and Podiatry, Universidad Complutense de Madrid, Madrid, Spain

3 CIBER Enfermedades Respiratorias-CIBERES (CB06/06/0058), Madrid, Spain

4 Intermal Medicine Department, Hospital General Universitario Gregorio Marañón, Madrid, Spain

5 Geriatric Department, Hospital General Universitario Gregorio Marañón, Madrid, Spain

6 Instituto de Investigación Sanitaria Gregorio Marañón, Madrid, Spain

7 Biomedical Research Networking Centre On Frailty and Healthy Ageing, CIBERFES, Madrid, Spain

8 Department of Medicine, School of Medicine, Universidad Complutense, Madrid, Spain

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Introduction

Intravascular catheters are an indispensable part of appropriate patient management. However, indwelling time is directly related to the risk of complications, such as phlebitis, which, despite being a physical–chemical phenomenon, can facilitate infection [1–6]. Wearing a catheter is also complicated by colonization resulting from manipulation, as this is the first step towards catheter-related bloodstream infection (C-RBSI), whose morbidity and mortality, and related costs are high [7–10].

We now know that most cases of C-RBSI occur in non-tunneled central venous catheters (CVCs), although the increased use of peripheral venous catheters (PVCs) has also led to an increase in peripheral line-related bloodstream infection (PL-RBSI) [2, 3, 11–16]. The main etiological agent in C-RBSI is coagulase-negative staphylococci, whereas in PL-RBSI the main etiological agent is *Staphylococcus aureus*, whose virulence and pathogenicity are greater, again leading to higher morbidity and mortality [3, 12, 14–18].

A few years ago, our research group performed a multicenter project to study the use of endovascular catheters in internal medicine departments in Spain (the "NUVE" Project). We found that the incidence of PL-RBSI was high and that there were opportunities for improvement during insertion and maintenance of PVCs [13, 14].

Therefore, it is necessary to implement and ensure adherence to recommendations to reduce complications associated with the use of PVCs [19]. Since it is difficult to monitor the efficacy of these measures throughout a center, we designed a pre-post-intervention study to analyze and compare the complication rates associated with the use of PVC after implementation of a training bundle in a geriatrics department, where PVCs frequently play a role in patient care.

Materials and methods

Setting

The study was performed in a 1550-bed tertiary teaching hospital in Madrid, Spain, with a catchment population of 715,000 inhabitants. The Geriatrics Department contains 18 beds and receives an average of 60–80 patients/month. The average age of the patients is 89 years, and the mortality rate is 14%. All admitted patients have at least 1 PVC inserted, with an average indwelling time of 7 days.

Design

Observational, pre-post-intervention study to analyze the impact of an interventional bundle on the reduction of complications associated with the use of PVCs.

We included adult patients hospitalized in the Geriatrics Department whose PVC was inserted anywhere in the hospital less than 24 h after insertion, whose life expectancy was > 48–72 h, and whose PVC had an expected indwelling time of more than 24 h. In addition, there could be no evidence or suspicion of PL-RBSI at enrolment. Patients had to have signed the informed consent after reading the patient information sheet. Patients with dementia or unable to sign were not included. Nurses filled daily the catheter data in the data collection notebook. Patients' follow-up was performed daily always by the same medical researcher.

Preventive measures during both periods

Pre-intervention (10 months)

Catheter manipulation included hand hygiene with alcohol-based solutions, use of clean gloves during insertion, daily recording of the need for catheter use, daily monitoring of the insertion site, skin disinfection with 2% alcoholic chlorhexidine, disinfection of the connector with 70% alcohol wipes before use, replacement of gauze/transparent dressing according to international guidelines, and use of split-septum closed connectors (CLAVE, ICU Medical, Inc., San Clemente, CA, USA).

Post-intervention (9 months)

Catheter manipulation included all the recommendations of the pre-intervention period in addition to an interventional bundle based on the following measures: periodic educational and training talks in all nursing units, with special attention given to the emergency department, use of novel didactic material (posters, leaflets, and protocols, with new recommendations on measures for insertion and maintenance of PVC (supplementary material)), use of saline solution (PosiFlush™, Becton Dickinson; New Jersey, USA) for catheter maintenance, use of sterile gloves for PVC insertion, use of 2% alcoholic chlorhexidine wipes in single-dose format for skin disinfection prior to insertion of the PVC, replacement of alcohol-impregnated wipes by passive disinfection with 70% alcohol–impregnated caps (Curos™, 3 M, Minnesota, USA), and catheter replacement only when clinically indicated.

In both periods, medication was taken orally, whenever possible.

Definitions

- Catheter colonization: isolation of a microorganism(s) in a significant count (≥ 15 cfu/plate).
- Phlebitis: presence of redness, swelling, tenderness, and/or inflammation.
- Peripheral line-associated bloodstream infection: defined based on the guidelines for diagnosis and management

of catheter-related infection, which consists of fever in a patient with an indwelling PVC for at least 48 h and no other possible source of infection.

– PL-RBSI: microbiological confirmation of the PVC as the source of the bloodstream infection, i.e., detection of the same microorganism(s) in catheter culture and in peripheral blood cultures.

Statistical and clinical analysis

Qualitative variables are expressed as a frequency distribution. Quantitative variables are expressed as the mean and standard deviation (SD) and as the median and interquartile range (IQR) in the case of a non-normal distribution. Continuous variables were compared using the *t* test in the case of a normal distribution and the median test in the case of a non-normal distribution. The chi-square or Fisher exact test was used to compare categorical variables.

The variables included in the multivariate logistic analysis for phlebitis were those that proved significant and those considered clinically relevant.

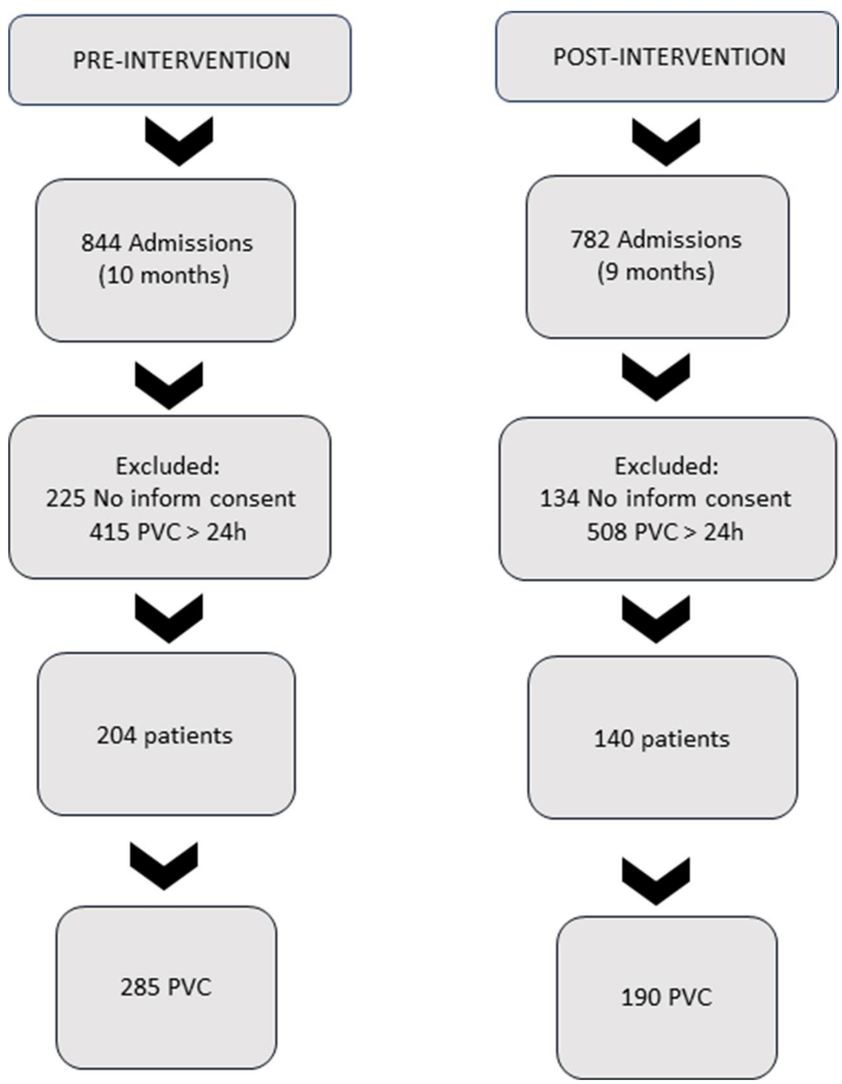
Statistical significance was set at $p < 0.05$ for all the tests. The statistical analysis was performed using SPSS 21.0.

Results

When we compared the results obtained before the implementation of the bundle (Nov 20–Aug 21) with those recorded during the implementation of the bundle (Oct 21–Jun 22), we found no statistically significant differences regarding phlebitis or catheter tip colonization rates.

We included a total of 344 patients with 475 PVCs inserted. These were distributed as follows: pre-intervention period, 204 patients (285 PVCs); post-intervention period, 140 patients (190 PVCs) (Fig. 1).

Fig. 1 Flowchart of patients' inclusion in the study



Characteristics of the study population

The median age was 89.0 (86.0–93.0) years, and 61.0% of patients were female. The main underlying condition was heart failure (18.0%), which was significantly higher during the post-intervention period (13.7% vs 24.3%, $p=0.012$). The median (IQR) length of hospital stay was 8.0 (5.0–16.0) days. The median (IQR) APACHE II score was 10.0 (7.0–13.0), although this was significantly higher during the pre-intervention period (11.5 [8.0–15.30] vs. 8.0 [6.0–10.0], $p<0.001$). In addition, the McCabe score was also significantly different between the study periods, as 42.6% of patients died in the pre-intervention period compared with 0.7% in the post-intervention period ($p<0.001$). The number of patients with sepsis was higher in the post-intervention period ($p=0.002$) (Table 1).

Characteristics of the catheters

Indwelling time

Median (IQR) PVC indwelling time was 3.0 (2.0–6.0) days, and 233 (49.1%) were inserted for more than 3 days. In those PVCs that were inserted for > 3 days, we did not find statistically significant differences in the complication rate according to insertion site (Table 2).

Department of insertion

Significantly more PVCs were inserted in the emergency room during the pre-intervention period than in the post-intervention period (29.1% vs. 15.8%, $p=0.001$), and 54% of the PVCs inserted in the emergency room were placed in the hand (Table 2).

Site of insertion

The PVCs were inserted at the following sites: hand, 62.1%; forearm, 14.7%; antecubital fossa, 9.3%; and arm, 13.9% (Table 2). Of the 295 and 66 PVCs inserted in the hand and in the arm, respectively, only 88 (29.8%) and 10 (15.2%) led to phlebitis ($p=0.018$ and $p=0.034$).

Indication for use

Serum therapy during the pre- and post-intervention periods was administered to 22.8% and 8.4% of patients, respectively ($p<0.001$). In contrast, antimicrobial therapy was more frequent in the post-intervention period: 46% vs. 54.7% ($p=0.061$) (Table 2).

Reason for catheter withdrawal

The main reason for catheter withdrawal was obstruction/malfunctioning (33.3%), with the extravasation rate being significantly more frequent in the post-intervention period (4.9% vs. 13.7%, $p=0.001$). A total of 158 PVCs were removed because of obstruction. This was more common for the hand than for other sites (55.7% vs. 44.3%, $p=0.045$). In addition, obstruction was less frequent in the 113 PVCs inserted in the emergency room and the 81 PVCs used for serum therapy ($p=0.039$ and $p=0.013$).

Clinical signs at the insertion site

Erythema was more frequent in the post-intervention period (22.1% vs. 14.7%, $p=0.039$). Positive cultures were recorded in only 10 (11.9%) out of the 84 PVCs (17.7%) removed because of suspected infection and in 22 (16.1%) of the 137 (28.8%) PVCs removed because of end of use.

Complications

The frequency of colonization was 10.5% (50/475) and that of phlebitis 26.1% (124/475), that is, 30.8/1,000 admissions and 76.3/1,000 admissions, respectively. The colonization rate was significantly lower among PVCs that were inserted in the antecubital fossa (9/44, 20.5%; 35/44, 79.5%; $p=0.036$).

Etiology

Of the 50 colonized PVCs, a total of 74 microorganisms were isolated. These were distributed as follows: Gram positive, 93.2%; Gram negative, 2.7%; and yeasts, 4.1%. *Staphylococcus epidermidis* and other coagulase-negative staphylococci were the most frequent (67.6%). *Staphylococcus aureus* was not isolated (Table 3).

Table 4 presents the results of the multivariate logistic regression analysis, which showed that insertion in the hand was a protective factor for phlebitis (OR = 0.399, p = 0.013, 95% confidence interval: 0.193–0.825).

Discussion

Our study shows that a preventive bundle for insertion and maintenance of PVCs in elderly patients admitted to a geriatric department may help to decrease phlebitis and colonization rates.

PVCs are frequently inserted to administer drugs, fluids, and nutrients [20], although their use is associated with

Table 1 Patients' description

Characteristic	Overall, *N* = 344	Pre-intervention period, *N* = 204 (59.3%)	Post-intervention period, *N* = 140 (40.7%)	*p*
Median (IQR) age, years	89.0 (86.0–93.0)	89.0 (85.0–93.0)	89.0 (86.0–92.0)	0.257
Sex, *N* (%)				0.500
Male	134 (39.0)	76 (37.3)	58 (41.4)	
Female	210 (61.0)	128 (62.7)	82 (58.6)	
Reason for hospital admission, *N* (%)				**0.010**
Heart failure	62 (18.0)	28 (13.7)	34 (24.3)	**0.012**
Gastrointestinal disease	44 (12.8)	24 (11.8)	20 (14.3)	0.492
Pneumonia	42 (12.2)	26 (12.7)	16 (11.4)	0.714
UTI	40 (11.6)	21 (10.3)	19 (13.6)	0.352
Constitutional syndrome	20 (5.8)	10 (4.9)	10 (7.1)	0.383
Ictus	18 (5.2)	10 (4.9)	8 (5.7)	0.740
COPD	15 (4.4)	9 (4.4)	6 (4.3)	0.955
SOT	14 (4.1)	11 (5.4)	3 (2.1)	0.134
Hematologic malignancy	11 (3.2)	3 (1.5)	8 (5.7)	**0.028**
Renal failure	10 (2.9)	7 (3.4)	3 (2.1)	0.485
Fever	7 (2.0)	6 (2.9)	1 (0.7)	0.151
Pleural effluxion	6 (1.7)	5 (2.5)	1 (0.7)	0.227
PTE	2 (0.6)	2 (1.0)	0 (0.0)	0.240
Other	52 (15.0)	41 (20.1)	11 (7.9)	**0.002**
Median (IQR) hospital stay, days	8.0 (5.0–16.0)	8.0 (5.0–12.0)	8.5 (5.0–18.8.0)	0.987
Median (IQR) APACHE II score	10.0 (7.0–13.0)	11.5 (8.0–15.0)	8.0 (6.0–10.0)	**< 0.001**
McCabe, *N* (%)				**< 0.001**
1 fatal	88 (25.6)	87 (42.6)	1 (0.7)	**< 0.001**
2 ultimately fatal	103 (29.9)	58 (28.4)	45 (32.1)	0.460
3 non-fatal	153 (44.5)	59 (28.9)	94 (67.1)	**< 0.001**
Mean (SD) no. PVCs	1.38 (0.76)	1.40 (0.83)	1.36 (0.37)	0.750
Infection, *N* (%)	164 (47.7)	83 (40.7)	81 (57.9)	**0.002**
Urinary	67 (19.5)	37 (18.1)	30 (21.4)	0.266
Respiratory	56 (16.3)	25 (12.3)	31 (22.1)	0.323
Bacteriemia	12 (3.5)	3 (1.5)	9 (6.4)	0.072
CD diarrhoea	7 (2.0)	6 (2.9)	1 (0,7)	0.053
IE	1 (0.3)	1 (0.5)	0 (0.0)	0.316
Other	21 (6.1)	10 (4.9)	11 (7.9)	0.815
Fever, *N* (%)	14 (4.1)	6 (2.9)	8 (5.7)	0.184
Sepsis, *N* (%)	21 (4.4)	9 (3.2)	12 (6.3)	0.101
Crude mortality, *N* (%)	36 (10.5)	22 (10.8)	14 (10.0)	0.860
Systemic antimicrobials, *N* (%)	214 (62.2)	109 (53.4)	105 (75.0)	**< 0.001**
Median (IQR) antimicrobial days	7.0 (5.0–8.0)	7.0 (5.0–10.0)	7.0 (5.0–8.0)	0.147
Median (IQR) DDDs	7.0 (5.0–12.0)	8.0 (5.0–13.0)	7.0 (5.0–11.0)	**0.007**

IQR, interquartile range; *UTI*, urinary tract infection; *SD*, standard deviation; *SOT*, solid organ tumor; *PTE*, pulmonary thromboembolism; *PVC*, peripheral venous catheter; *CD*, *Clostridium difficile*; *IE*, infective endocarditis; *DDD*, define daily doses

complications and risk factors [2, 6, 9]. Most studies assessing complications and risk factors associated with PVCs are carried out in heterogeneous populations [21–26]. However, since few clinical studies have been performed with elderly patients [27], we aimed to describe the characteristics of this population in terms of complications of PVCs during insertion and maintenance before and after a care bundle.

The measures currently recommended by major international guidelines for the prevention of intravascular device-related infections focus on the implementation of programs of continuing education, surveillance, and maximum adherence to aseptic techniques and procedures, especially at the time of catheter insertion and in the handling of connections and infusion systems [20, 28, 29], as well as flushing

Table 2 Catheters' description

Characteristic	Overall, *N* = 475	Pre-intervention period, *N* = 285 (60.0%)	Post-intervention period, *N* = 190 (40.0%)	*p*
Median (IQR) catheter indwelling time, days	3.0 (2.0–6.0)	3.0 (2.0–6.0)	3.0 (2.0–5.3)	0.164
Catheter duration, *N* (%)				0.708
0–3 days	242 (50.9)	143 (50.2)	99 (52.1)	
> 3 days	233 (49.1)	142 (49.8)	91 (47.9)	
Insertion at, *N* (%)				**0.003**
Geriatric department	349 (73.5)	194 (68.1)	155 (81.6)	**0.001**
Emergency room	113 (23.8)	83 (29.1)	30 (15.8)	**0.001**
Other	13 (2.7)	8 (2.8)	5 (2.6)	0.909
Site of insertion, *N* (%)				0.825
Hand	295 (62.1)	176 (61.8)	119 (62.6)	0.847
Forearm	70 (14.7)	40 (14.0)	30 (15.8)	0.597
Antecubital fosse	44 (9.3)	29 (10.2)	15 (7.9)	0.401
Arm	66 (13.9)	40 (14.0)	26 (13.7)	0.914
Indication use, *N* (%)				**0.001**
Antimicrobial therapy	235 (49.5)	131 (46.0)	104 (54.7)	0.061
Serum therapy	81 (17.1)	65 (22.8)	16 (8.4)	**< 0.001**
Parenteral nutrition	6 (1.3)	3 (1.1)	3 (1.6)	0.615
Other	153 (32.2)	86 (30.2)	67 (35.3)	0.245
Reason for catheter withdrawal, *N* (%)				**0.012**
Obstruction/malfunctioning	158 (33.3)	100 (35.1)	58 (30.5)	0.277
End of use	137 (28.8)	81 (28.4)	56 (29.5)	0.804
Suspicion of infection	84 (17.7)	50 (17.5)	34 (17.9)	0.922
Accidental	55 (11.6)	39 (13.7)	16 (8.4)	0.079
Pulled out by the patient	1 (0.2)	1 (0.4)	0 (0.0)	0.414
Extravasation	40 (8.4)	14 (4.9)	26 (13.7)	**0.001**
Appearance of site of infection, *N* (%)				
Phlebitis	124 (26.1)	69 (24.2)	55 (28.9)	0.250
Pain	74 (15.6)	42 (14.7)	38 (16.8)	0.535
Erythema	84 (17.7)	42 (14.7)	42 (22.1)	**0.039**
Induration	70 (14.7)	37 (13.0)	33 (17.4)	0.186
Pus	1 (0.2)	0 (0.0)	1 (0.5)	0.220
Phlebitis per 1000 admissions	76.3	81.5	65.1	0.457
PCV colonization, *N* (%)	50 (10.5)	31 (10.9)	19 (10.0)	0.760
PVC colonization per 1000 admissions	30.8	36.7	24.3	0.198
Infection, *N* (%)	18 (3.8)	5 (1.8)	13 (6.8)	0.652
Respiratory	4 (0.8)	1 (0.4)	3 (1.6)	
Urinary	5 (1.1)	2 (0.7)	3 (1.6)	
Abdominal	3 (0.6)	0 (0.0)	3 (1.6)	
Other	6 (1.3)	2 (0.7)	4 (2.1)	

SD, standard deviation; *PVC*, peripheral venous catheter; *PVC-RBSI*, peripheral venous catheter-related bloodstream infection

using pre-filled flush syringes [30–32]. In particular, it has been shown that both educational and interventional measures, collectively referred to as a *bundle*, should be added, although these measures are more stringent for CVCs than for PVCs [33]. National and international preventive programs continue to be implemented to reduce complications associated with CVC use [34]; however, data on programs targeting PVCs are scarce and controversial [35–37]. In particular, Lladó Maura et al. showed that the incidence of PL-RBSI decreased from 0.48 episodes per 1000 patient-days in 2015 to 0.17 episodes per 1000 patient-days in 2018, whereas data from the pre-post-intervention study within the

Table 3 Microorganisms' distribution in colonized peripheral venous catheters

Microorganisms, *N* (%)	Overall, *N* = 74	Pre-intervention period, *N* = 42 (56.8%)	Post-intervention period, *N* = 32 (43.2%)	*p*
Gram positive	**69 (93.2)**	**38 (90.5)**	**31 (96.9)**	0.516
Staphylococcus epidermidis	29 (39.2)	16 (38.1)	13 (40.6)	
Other coagulase-negative Staphylococci	21 (28.4)	11 (26.2)	10 (31.3)	
Corynebacterium spp.	16 (21.6)	9 (21.4)	7 (21.9)	
Enterococcus faecalis	1 (1.4)	0 (0.0)	1 (3.1)	
Enterococcus faecium	1 (1.4)	1 (2.4)	0 (0.0)	
Arthrobacter cumminsii	1 (1.4)	1 (2.4)	0 (0.0)	
Gram negative	**2 (2.7)**	**2 (4.8)**	**0 (0.0)**	
Enterobacter cloacae	1 (1.4)	1 (2.4)	0 (0.0)	
NFGNB	1 (1.4)	1 (2.4)	0 (0.0)	
Yeasts	**3 (4.1)**	**2 (4.8)**	**1 (3.1)**	
Candida albicans	2 (2.7)	1 (2.4)	1 (3.1)	
Candida glabrata	1 (1.4)	1 (2.4)	0 (0.0)	

NFGNB, non-fermented gram-negative bacilli

Table 4 Multivariate analysis of risk factors for phlebitis

Variable	Odds ratio	β	*p*	95%CI
Catheter indwelling time > 3 days	1.240	0.215	0.315	0.815–1.887
Insertion at hand	**0.399**	− 0.919	**0.013**	0.193–0.825
Insertion at forearm	0.718	− 0.331	0.470	0.292–1.764
Insertion at antecubital fossa	0.471	− 0.752	0.125	0.180–1.232
Serum therapy	1.126	0.118	0.720	0.589–2.151
Antimicrobial therapy	0.857	− 0.154	0.519	0.536–1.370
Insertion at emergency room	1.505	0.409	0.098	0.927–2.443
Bundle intervention	0.736	− 0.307	0.167	0.476–1.137

CI, confidence interval

VINCat programme by Freixas et al., which included both CVCs and PVCs, showed no statistically significant reduction in PL-RBSI after implementation preventive measures [38]. Our data are similar to those of Freixas et al., in that we did not significantly reduce phlebitis and/or colonization of PVCs, despite a decrease between the study periods in the incidence of phlebitis from 81.5/1000 admissions to 65.1/1000 admissions and in the incidence of colonization from 36.7/1000 admissions to 24.3/1000 admissions.

Several studies have attempted to identify risk factors associated with phlebitis. In one of our previous studies performed in the internal medicine department, we reported a phlebitis rate of 62.9% and found that the risk of phlebitis was 5 times higher when the PVC was inserted in the emergency department [13, 14]. Other authors also considered that PVCs inserted in the emergency department should be routinely replaced within 48 h [14, 39, 40]. However, in the present study, we did not find statistically significant differences for the phlebitis rate among PVCs inserted in the emergency department.

We found that only 54% of PVCs placed in the emergency department were inserted in the hand and that only 88 out of the 295 PVCs inserted in the hand were associated with phlebitis ($p = 0.018$). In addition, of the 66 PVCs inserted in the arm, only 10 were associated with phlebitis ($p = 0.034$). These data differ from those reported by other authors, which are controversial. Comparcini et al. showed that insertion in antecubital fossa veins was associated with a lower phlebitis rate, while insertion in hand veins carried the highest risk of phlebitis [41]. Fan et al. reported no significant differences between PVC placement in the forearm and the hand in terms of complications [42]. In addition, Buetti et al. demonstrated that PVCs inserted in the hand with > 3 days of indwelling time were less frequently associated with risk of PL-RBSI [43]. We were unable to corroborate this finding in our study: no significant differences were recorded regarding complications between PVCs inserted in the hand and other sites for the 233 PVCs with > 3 days of indwelling time.

The most frequent complication requiring catheter withdrawal was obstruction/malfunctioning (33.3%), in contrast with that reported in a meta-analysis including 76,977 PVCs, in which phlebitis was the major associated complication [44].

Another important finding was that of the 84 PVCs removed because of suspicion of infection, only 11.9% were eventually colonized. In contrast, of the 137 PVCs removed because of the end of use, 16.1% yielded a positive culture. This finding is supported by other authors, who reported that, of 297 PVCs that failed and needed to be removed, 41 yielded positive cultures and only 22 out of the 41 (53.6%) were from patients with clinical signs of infection [45]. Thus, it is important to ensure that the PVC is inserted in compliance with maximum sterile barriers and to remove the PVC when it cannot be ensured that it was inserted using the non-touch technique. It is also important to send PVC tips for culture when infection is suspected, even if there are no visible clinical signs of infection.

In summary, we consider that there is a need to implement bundles that combine both educational and interventional measures in a unified and consensual way for the insertion and maintenance of PVCs in hospitals, as well as to ensure adherence by healthcare staff.

The main limitation of our study was that it was performed in a single center and during the COVID-19 pandemic (affecting both pre and post-interventional, periods but without finding differences in infection rates between the two periods). In addition, we did not collect data regarding the insertion of a PVC in the previous week, which was shown to be a risk factor for catheter failure [23], or regarding the type of antibiotic administered and catheter size. Moreover, it is difficult to agree on recommendations owing to the heterogeneity of published studies [46]. Another limitation was the difficulty enrolling patients owing to their age or because the PVC had been inserted for > 24 h, without having registered the number in each period. It also would have been desirable to record the assessment of the activities of daily living (ADL or IADL) to ensure that both groups were comparable. Lastly, in the multivariate analysis, we only included variables related to the catheter, not to the patients, because of statistically significant differences in clinical characteristics.

Conclusion

The implementation of our bundle slightly reduces phlebitis and colonization rates, albeit not significantly. It is necessary to carry out randomized studies including all the risk factors to evaluate the most cost-effective measures for reducing complications associated with PVCs.

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Author contribution MG and MJPG were responsible for the organization and coordination of the trial. MG and JAS were the chief investigators and responsible for the data analysis. AIVS and NT collected the clinical data. ER, MLC, GH, and MK were responsible for the implementation of the bundle and patient recruitment. PM and JAS approved the final manuscript. All authors contributed to the writing of the final manuscript.

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Data availability Data sharing is not applicable to this article, as no datasets were generated or analyzed during the study.

Code availability Not applicable.

Declarations

Ethics approval The study was approved by the local ethics committee (MICRO.HGUGM.2018–005).

Consent to participate All of the patients included in the study signed the informed consent document.

Consent for publication Not applicable.

Conflicts of interest The authors declare no competing interests.

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