International Journal of Nursing and Health Care Research

Pérez-Granda MJ, et al. Int J Nurs Health Care Res 6: 1480

www.doi.org/10.29011/2688-9501.101480

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Research Article

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

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Citation: Pérez-Granda MJ, Ferrer MS, Alcaraz MT, Cobos S, Cuenca A, et al. (2023) Impact of An Interventional Bundle on Complications Associated with Peripheral Venous Catheters in Children Admitted to A Cardiology Department. Int J Nurs Health Care Res 6:1480. DOI: https://doi.org/10.29011/2688-9501.101480

Received Date: 04 November, 2023; **Accepted Date:** 10 November, 2023; **Published Date**: 14 November, 2023

Abstract

Peripheral venous catheters (PVCs) are frequently inserted in children. However, their use is associated with difficulties during insertion and complications during management. Our objective was to assess an interventional care bundle for insertion of PVCs in pediatric patients admitted to a cardiology department. Over a 10-month period, we prospectively included pediatric patients with a PVC inserted in the cardiology department. The study period comprised a 4-month pre-intervention period, followed by a 6-month post-intervention period, in which a preventive bundle was implemented. Data regarding catheter insertion, nursing experience, and complications were collected. Patients were monitored daily until catheter withdrawal. We included a total of 30 and 41 patients with 50 and 83 PVCs inserted during the 2 periods, respectively. Most PVCs were inserted in the forearm (36.8%). Younger patients experienced more severe pain at insertion (p=0.003), although this was significantly reduced after implementation of the bundle (34% vs 12%, p<0.001). No statistically significant reduction was observed in the frequency of phlebitis and of colonization in both periods (6.0% vs. 9.6% [p=0.53] and 6.6% vs. 12.3% [p=0.47], respectively). **Conclusion**: Our preventive bundle was able to reduce severe pain during insertion of PVCs. However, it was unable to reduce phlebitis and infection rates, suggesting that further preventive measures are needed to improve management of PVCs in children admitted to cardiology departments.

Keywords: Peripheral venous catheter; Children; Pain; Phlebitis; Complications; Bundle

Abbreviations: PC-RBSI: Peripheral catheter-related bloodstream infection; PVC: Peripheral venous catheter

Introduction

Peripheral venous catheters (PVCs) are frequently used in children for the administration of drugs, fluids, and nutrients. It is estimated that more than 80% of patients are catheterized during hospitalization [1].

However, insertion of a PVC is more difficult in children than in adults because of intrinsic factors such as weak and thin vessels and thicker adipose tissue and environmental factors (eg, crying and stress) [2], all of which make insertion the leading source of procedure-related pain in the hospital [1,3,4]. Consequently, insertion leads to complications in 24.8% to 51.9% of pediatric patients, with the highest frequencies recorded in neonates. This frequency decreases with the child's age [1,5-7].

Phlebitis is one of the most frequent complications associated with insertion of a PVC. A meta-analysis of adult patients reported an incidence rate of 31% [8]. However, in the pediatric population, percentages ranged from 5% to 53.4% owing to differences in the definition of phlebitis and in the type of patients included [2, 9-11].

Although current guidelines for prevention of catheter-related infections are aimed specifically at central venous catheters [12], PVCs are more susceptible to phlebitis and inadequate handling [13-17]. Several studies have assessed the impact of preventive bundles on PVC-related complications [18,19]. However, studies assessing these bundles in the pediatric population are scarce [20].

Therefore, it is necessary to carry out studies in pediatric patients with PVCs to assess the impact of preventive programs and thus improve the use and maintenance of these catheters.

We prospectively assessed insertion of PVCs and associated complications in children admitted to a cardiology department before and after implementation of an interventional bundle.

Material and Methods

The study was carried out in the Pediatric Cardiology Department of Hospital General Universitario Gregorio Marañón (Madrid, Spain), which generally has 18 beds. Ours is a tertiary teaching hospital with approximately 1,550 beds and a catchment population of 750,000.

Over a 10-month period, we included pediatric patients (0-18 years) with a PVC inserted in the Pediatric Cardiology Department. The patient's signed informed consent was obtained in each case. When it was not possible to obtain informed consent, the patient was excluded from the study. Patients were provided with an information sheet before giving their informed consent.

All healthcare workers from the department were informed of the content of the study. Nurses were also trained in adequate patient monitoring and implementation of the bundle, and data regarding their experience in the department were collected.

Patients were monitored daily until withdrawal, and all necessary data were recorded.

The complications included pain during insertion, number of insertion attempts, phlebitis, catheter colonization, and Peripheral Catheter-Related Bloodstream Infection (PC-RBSI).

All withdrawn PVCs were sent to the microbiology laboratory for culture based on the semi-quantitative roll-plate technique (Maki). Blood cultures were obtained when there was suspicion of PC-RBSI.

Preventive measures during both periods

Pre-intervention (4 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 (6 months). Catheter manipulation included all the recommendations of the pre-intervention period in addition to an interventional bundle based on the use of saline solution (PosiFlush®) in the maintenance of catheters and the replacement of alcohol-impregnated wipes by caps impregnated in antiseptic for disinfection of the connector.

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 peripheral venous catheter for at least 48 hours and no other possible source of infection.
- PC-RBSI: Microbiological confirmation of the catheter as the source of the bloodstream infection, ie, detection of the same microorganism(s) in catheter culture and in peripheral blood cultures.

- Pain was assessed in children aged >24 months using a visual analogue scale of 6 grades of pain ranging from none to very severe. Pain was assessed in children <24 months by analyzing facial gestures.

Statistical and Clinical Analysis

Qualitative variables appear with their frequency of distribution; quantitative variables are expressed as the median and Interquartile Range (IQR). Non-normally distributed continuous variables were compared using the median test. The chi-squared or Fisher exact test was used to compare categorical variables. The Spearman test was used to correlate the child's age with the degree pain during insertion.

Statistical significance was set at $p<0.05$ for all the tests. The statistical analysis was performed using IBM SPSS Statistics for Windows, Version 21.0 (IBM Corp, Armonk, New York, USA).

Results

Overall

Of a total initial sample of 565 admissions, we finally included 71 patients with 133 PVCs inserted. The remaining 494 patients were excluded because the PVC had been inserted in another unit (n=257), the PVC was no longer needed (n=231), or the informed consent was not obtained (n=6) (Figure 1).

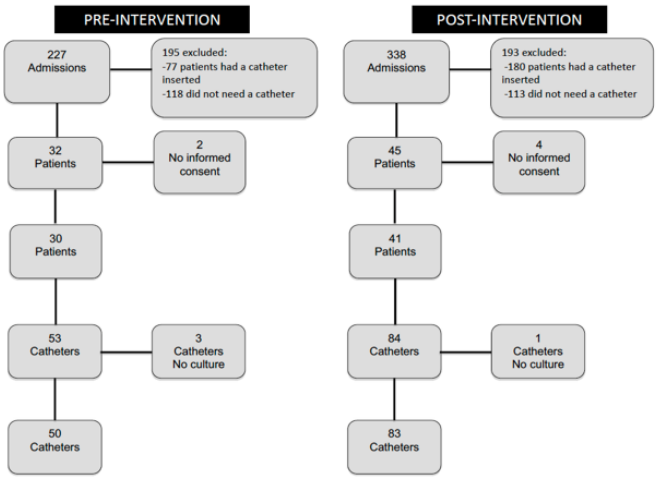

Figure 1: Flowchart of patients' inclusion in the study.

Overall, the median age was 7.44 (2.61-13.62) years, and 54.9% of patients were male. The median (IQR) length of hospital stay was 2.0 (1.00-9.00) days, which was significantly reduced during the post-interventional period (6.00 [2.00-10.00] vs. 2.00 [1.00-7.50], p=0.008).

One episode of methicillin-susceptible Staphylococcus aureus PC-RBSI was recorded for a PVC inserted in the forearm for 7 days during the pre-intervention period, ie, an overall PC-RBSI rate of 1.4 episodes/1,000 admissions (Table 1). The catheter was removed because of end of use.

Characteristic	Total, N=71	Pre-intervention, N=30	Post-intervention, N=41	p
Median (IQR) age, years	7.44 (2.61-13.62)	8.67 (2.62-11.66)	5.47 (2.23-14.12)	1.00
Sex, N (%)				
Male	39 (54.9)	19 (63.3)	20 (48.7)	0.24
Female	31 (43.7)	11 (36.7)	21 (51.2)	
Median (IQR) days of hospital stay (days)	2.00 (1.00-9.00)	6.00 (2.00-10.00)	2.00 (1.00-7.500)	0.008
Median (IQR) days in cardiology department	2.00 (1.00-7.00)	5.00 (2.00-9.00)	2.00 (1.00-5.00)	0.12
Admissions, N	565	227	338	NA
Catheter colonization, N (%)	7 (9.8)	2 (6.6)	5 (12.3)	0.47
Catheter colonization, no. of episodes /1,000 admission	12.38	8.81	14.79	0.80

Median (IQR) catheter indwelling time in colonized patients, days	6.0 (3.0-15.0)	5.5 (4.0-5.5)	6.0 (2.0-29.0)	<0.001
PC-RBSI, N (%)	1 (1.4)	1 (3.3)	0 (0.0)	0.37
Bacteremia, no. of episodes/1,000 admissions	1.76	4.40	0.00	0.84

Table 1: Demographic and clinical characteristics of the patients.

The frequency of colonization was 9.8% (7/71) and that of phlebitis 8.3% (11/133), with a median (IQR) indwelling time of 6.0 (3.0-15.0) and 7.0 (7.0-7.0) days. Of the 7 colonized catheters, 5 were removed because of end of use and 2 because of suspicion of infection, although no clinical signs of infection were observed.

Most of the 133 PVCs were inserted during the morning nursing shift (85.7%). The nurses who inserted the PVCs in the hospital and in the Pediatric Cardiology Department had a median of 15.0 (3.5-27.0) and 12.9 (4.5-19.0) years' experience, respectively. The PVCs were inserted at the following sites: forearm, 36.8%; feet, 22.6%; hand, 23.3%; antecubital fossa, 6.0%; arm, 3.8%; and scalp, 1.5% (Table 2).

The median duration of catheter insertion was 10.0 (3.0-10.0) minutes, and the median number of insertions attempts by the nurses was 1.0 (1.0-2.0). Median catheter indwelling time was 2.0 (1.0-3.0) days (Table 2). The main reason for catheter withdrawal was end of use (79.7%), followed by obstruction (9.0%) and suspicion of infection (6.8%) (Table 2).

Comparison between study periods

We found no statistically significant differences between patients' demographic characteristics (Table 1). During the pre-intervention period, pain during insertion was classed as medium in 44.0%, severe or very severe in 34.0%, and mild or very mild in 18.0%. No pain was recorded in the remaining 4.0% (Table 2). In contrast, after the implementation of the bundle, pain was severe or very severe in only 12%, medium in 22.9%, mild or very mild in 47%, and absent in 19.3% (p<0.001) (Table 2). We also found that younger patients (0-5 years) felt more severe pain at the time of insertion (p=0.003) during both study periods (p<0.001).

Characteristic	Total, N=133	Pre-intervention, N=50	Post-intervention, N=83	p
Time (nursing shift) when the catheter was inserted, N (%)				0.85
Morning	114 (85.7)	42 (84.0)	72 (86.7)	
Afternoon	16 (12.0)	7 (14.0)	9 (10.8)	
Night	3 (2.3)	1 (2.0)	2 (2.4)	
Catheter location, N (%)				0.06
Forearm	49 (36.8)	21 (42.0)	28 (33.7)	
Feet	30 (22.6)	12 (24.0)	18 (21.6)	
Hand	39 (29.3)	8 (16.0)	31 (37.3)	
Antecubital fossa	8 (6.0)	4 (8.0)	4 (4.8)	
Arm	5 (3.8)	3 (6.0)	2 (2.4)	
Scalp	2 (1.5)	2 (4.0)	0 (0.0)	

Degree of pain during the insertion*, N (%)				<0.001
None	18 (13.5)	2 (4.0)	16 (19.3)	
Very mild	22 (16.5)	2 (4.0)	20 (25.3)	
Mild	25 (18.8)	7 (14.0)	18 (21.7)	
Medium	41 (30.8)	22 (44.0)	19 (22.9)	
Severe	23 (17.3)	16 (32.0)	7 (8.4)	
Very severe	4 (3.0)	1 (2.0)	3 (3.6)	
Median (IQR) duration of catheter insertion, minutes	10.0 (3.0-10.0)	10.0 (5.0-10.0)	5.0 (3.0-10.0)	0.50
Median (IQR) number of insertion attempts	1.0 (1.0-2.0)	1.0 (1.0-2.0)	1.0 (1.0-2.0)	0.75
Median (IQR) catheter indwelling time, days	2.0 (1.0-3.0)	2.0 (1.0-4.2)	3.0 (2.0-4.0)	0.10
Phlebitis, N (%)	11 (8.3)	3 (6.0)	8 (9.6)	0.53
PC-RBSI, N (%)	1 (0.8)	1 (2.0)	0 (0.0)	0.37
Reason for catheter withdrawal, N (%)				0.52
End of use	106 (79.7)	37 (74.0)	69 (83.1)	
Obstruction	12 (9.0)	7 (14.0)	5 (6.0)	
Suspicion of infection	9 (6.8)	3 (6.0)	6 (7.2)	
Other	6 (4.5)	3 (6.0)	3 (3.6)	

Table 2: Characteristics of the catheters.

For nurses, the median (IQR) years of experience in the hospital was significantly lower during the post-intervention period (24.0 [14.0-29.0] vs. 8.0 [1.0-18.0], p<0.001), whereas no differences were found according to experience in the Pediatric Cardiology Department (11.0 [2.0-16.0] vs. 15.0 [6.0-24.0], p=0.639).

Of the 7 colonized catheters, 2 and 5 (6.6% and 12.3%) were from the pre-intervention and post-intervention periods, respectively (p=0.47). The 11 cases of phlebitis were distributed as 3 and 8 episodes (6.0% and 9.6%) in the pre-intervention and post-intervention periods, respectively (p=0.53).

Discussion

Our study shows that a preventive bundle for insertion of PVCs in children admitted to a cardiology department was not associated with a significant reduction in phlebitis or PC-RBSI rates. However, severe pain during insertion was reduced significantly.

PVCs are frequently inserted in children to administer drugs, fluids, and nutrients [21], although their use is associated with complications and risk factors [2,6,10]. Most pediatric studies assessing complications and risk factors associated with PVCs are carried out in general pediatric, oncology, or emergency departments [1,5,9]. However, since few clinical studies have been performed with patients admitted to specific departments, such as the cardiology department (where PVCs are frequently used) are scarce, we aimed to describe the characteristics of patients and catheters in terms of complications of PVCs and pain during insertion before and after a care bundle in patients admitted to a cardiology department.

Insertion of a PVC is often challenging in pediatric patients owing to difficulty visualizing the veins and patient anxiety [1,3,4]. However, in our study, the median (IQR) number of attempts to insert a PVC was 1.0 (1.0-2.0), mainly because nurses in the cardiology department were very experienced (median of 12.9 years' experience).

As for degree of pain, we recorded a significant reduction in severe and very severe pain between both study periods (34% vs. 12%, p<0.001). The use of alternative approaches during insertion, such as virtual reality technology, is an additional useful and effective measure for reducing pain and anxiety in patients undergoing cannulation that will be included in our preventive

program in the future [22-24]. Therefore, virtual reality will prove particularly useful in children who are admitted to the hospital regularly, such as children with heart conditions, especially, those under 5 years of age, who experience greater pain during insertion, as reported elsewhere [1,5-7].

Even though we found median (IQR) indwelling time to be only 2.0 (1.0-3.0) days, the complications associated with insertion of a PVC were frequent, comprising 11 episodes of phlebitis, 7 episodes of catheter colonization, and 1 episode of PC-RBSI. The frequency of colonization and PC-RBSI episodes (6 and 7 days of indwelling time, respectively) was higher, as the risk of infection increases with indwelling time [25, 26]. It is also important to highlight that no clinical signs of infection were observed in cases of colonization or PC-RBSI. Therefore, in children, both clinical monitoring and palpation of the catheter insertion site are necessary to prevent infection of PVCs.

With respect to the frequency of phlebitis (8.3%) and the difficulty comparing our results with those reported elsewhere, our study is limited by our clinical definition, which requires redness, swelling, tenderness, and/or inflammation to be observed and the presence/absence of phlebitis to be evaluated. However, other reported frequencies (ranging from 5% to 53.4%) are based on different ways of measuring phlebitis. Dos Santos et al. used the Infusion Nursing Society evaluation scale, which classifies phlebitis into 3 grades. Suliman et al. defined phlebitis as the presence of 2 or more signs and symptoms. Finally, Foster et al. classified phlebitis into 4 grades according to various clinical criteria [2,9,10].

The bacteraemia rate increased compared with the previous year (2019) from 3.97/1,000 admissions to 4.44/1,000 admissions during the 4-month pre-interventional period. However, this rate decreased to 0.00/1,000 admissions during the post-interventional period, although the difference was not statistically significant (p=0.84). The number of catheter colonization episodes/1,000 admissions increased from 8.81 to 14.79, although, again, the difference was not statistically significant (p=0.80).

The only other study to address the impact of a care bundle for PVCs in children was that by Kleidon et al., who reported that first-attempt insertion success and median PVC indwelling time improved in patients admitted to a tertiary pediatric hospital after implementation of a multilevel care bundle based on prompt removal, hourly inspection, vein patency, clean hands, and scrubbing of the hub [20]. However, no comparisons can be made with our data, because of differences in preventive measures and study population. Similarly, difficulties were also reported in a recent systematic review by Ray-Barruel et al., who stated that the effectiveness of PVC bundles is unclear owing to the lack of standardization of their components, which hampers comparison of reported outcomes. Therefore, further research is needed to select bundle components that are sufficiently effective to reduce PVC-related complications [19].

In summary, we consider that, although there were only 11 episodes of phlebitis and 1 episode of PC-RBSI, mainly due to the short indwelling time, this frequency was not insignificant, given our sample size and the duration of the study. Therefore, additional preventive measures must be implemented to avoid the complications associated with PVCs in children.

One of the main limitations of the study was the small sample size, because most patients admitted to the cardiology department had already had their PVC inserted in another unit (especially in the emergency department and hemodynamic department); hence our difficulty in recruiting patients. In addition, the low catheter indwelling time may be because patients were often admitted only for a 1-day treatment.

Conclusion

Insertion and management of PVCs must be improved in order to reduce complications, especially in children who are regularly admitted to the hospital. Additional preventive measures must be included in the care bundle.

Declarations

Funding

M. Guembe is supported by the Miguel Servet Program (ISCIII-MICINN, MS18/00008) from the Health Research Fund (FIS) of the Carlos III Health Institute (ISCIII), Madrid, Spain. The study was partially funded by grants from the ISCIII (PI18/00045, PI21/00344), the European Regional Development Fund (FEDER) "A way of making Europe" and Programa Intramural de Impulso a la Investigación I+D+i 2019 (Subprograma "proyectos de investigación en cuidados de enfermería").

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Availability of Data and Material

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

Authors' contributions

MG and MJPG were responsible for the organization and coordination of the trial. MJPG and CM was the chief investigator and responsible for the data analysis. MSF, MTA, SC, AC, MLP, NG, and EP developed the trial design and data collection. All authors contributed to the writing of the final manuscript. All members of the BUPECC Study Team contributed to the management or administration of the trial.

Ethics Approval

The study was approved by the Ethics Committee of Hospital general Universitario Gregorio Marañón (MICRO.HGUGM.2019-009).

Consent to Participate

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

Acknowledgements

We thank Thomas O'Boyle for his help in the preparation of the manuscript.

We thank the members of the BUPECC study group for their collaboration in the study: Inmaculada Carchenilla, Ana Beatriz Gómez Ortega, Anabel Martín Mayoral, Elisabet Grande Alonso, Gloria Pinero Díaz, Ana Vera Rodríguez, Paola Alcaide Bazán, Mª José Carballo Díaz, Aaron Merino Vega, María Díaz César, Raquel Arranz Cortés, Sandra Fernández Menéndez, Mª de la Peña Borrero Castaño, Laura Valtueña Cortés, Mª Teresa Bezunartea, Mª Dolores Roncero, Laura Maqueda, Irene Martínez Muñoz. We thank Irene Manzano Benito for her help with data collection and analysis.

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