

Making a difference? A retrospective review of peripherally inserted central catheters: A single-center experience in Colombia

SAGE Open Medicine

Volume 11: 1–6



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DOI: 10.1177/20503121231201349

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Abstract

Introduction: Peripherally inserted central catheters (PICCs) are an effective tool as a medical device in patients who require them. However, it is a procedure that has been associated with multiple complications and possible negative outcomes for the health of the patients. This paper seeks to describe the main complications derived from the insertion and maintenance of peripherally inserted central venous catheters (PICCs), based on the experience of a vascular accesses group in a cardiovascular center in Colombia.

Methods: A retrospective cross-sectional analytical study of the adult population undergoing PICC insertion at the Fundación Cardioinfantil-Instituto de Cardiología, during the period between 2019 and 2020 by the vascular access program, was performed.

Results: The frequency of any registered complication was 15.9% for 2019 and 11.2% for 2020. Bleeding at the procedure site occurred in 15.3% during 2019 and 7.0% in 2020, making it the most frequent complication during the procedure. All the variables of complications associated with infection (bacteremia, phlebitis, and catheter-related infection) showed a decrease in 2020 compared to the previous year. The central line-associated bloodstream infection registered for the year 2019 was 1.94 bacteremia's/1000 catheters-day compared to 0.29 bacteremia's/1000 catheters-day.

Conclusions: There has been a 4.7% reduction in the frequency of any registered complication after the implementation of the vascular access groups. Global and specific complications decreased significantly from 2019 to 2020. Notably, bacteremia, a common post-procedure complication, showed a substantial decrease in frequency compared to national and worldwide literature. It is also been described that complications associated with infection showed a decrease in 2020 compared to 2019. Whether or not all these findings are directly or somewhat related to the results stemming from the vascular access groups still needs further investigation.

Keywords

Peripherally inserted central venous catheters, complications, catheter-related bacteremia, vascular access group

Date received: 24 May 2023; accepted: 29 August 2023

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Table 1. Variables associated with infection definition.

Variable	Definition
Phlebitis	Inflammatory clinical changes at the puncture site and vein path
Bacteremia	Clinical signs of infection, in addition to the same type of microorganism found in both peripheral blood culture and catheter tip ^{20,*}
Catheter-associated infection	Clinical and systemic signs of infection, and only catheter tip culture isolation

*Bacteremia definition is taken from the CDC guidelines.

Introduction

In the out-patient and in-patient setting, peripherally inserted central catheters (PICCs) represent an effective medical device to meet the patient's short- and long-term treatment needs.¹ PICCs are a key device in current patient care, allowing adequate venous access for the infusion of multiple therapeutic agents, sclerosants, and irritants.² However, it is a procedure that has been found to have many related complications, ranging from bleeding at the procedure site to bacteremia and vascular injury,^{1–6} it can even lead to high mortality rates.^{4,7–9} In spite of this, PICCs continue to serve as an essential tool in modern patient care, providing suitable venous access for delivering a range of therapeutic agents, medications, and challenging substances.^{2,9,10} It is for this and many other reasons that the use of PICCs has increased notably worldwide.^{4,10,11} The reported rates of complications for PICC placement and maintenance in the global literature are as follows: 4% for mechanical complications, 3% for thrombosis, and 2% for infections.¹²

The main objective of this study is to describe the complications and identify any type of variation stemming from the institutional implementation of internal policies such as the vascular access (VA) program. The Fundación Cardioinfantil's VA program is a multidisciplinary group consisting of the Department of Surgery, Nursing, Interventional Radiology, and Critical Care. This focus group was implemented at the end of 2018, and since then, it has been socialized to all clinical departments about the indications, contraindications, and medical uses of such accesses. The creation of programs such as this one is widely supported in the literature, demonstrating as successful the conformation of work teams led by medical and nursing staff.^{13,14} The program makes use of ultrasound and electrocardiographic (ECG) guidance that guides the puncture and confirms the position of the catheter tip; these strategies are supported in the current literature, thus reducing the incidence of complications.^{15,16}

According to the Centers for Disease Control (CDC), in the United States, there is an estimated annual prevalence of 250,000 cases of bacteremia associated with the implantation of a central venous catheter.¹⁷ In Colombia, although few studies describe their experience and complications, the reported evidence shows an overall complication rate of

9%–11% with infection rates of 1.4/1000 catheter-days.^{18,19}

In this study, the complications related to infection that were evaluated are bacteremia, phlebitis, and catheter-related infection, and are defined in Table 1.

Finally, through this paper, the authors aim to generate effective and safe improvement opportunities for patients who require these devices for their treatment. This project is carried out with the purpose of describing the main complications derived from the insertion and maintenance of peripherally inserted central venous catheters (PICCs) in patients who underwent the procedure at the Fundación Cardioinfantil-IC in charge of the VA group in the period from 2019 to 2020.

Methods

Type and design of the study

A retrospective cross-sectional analytical observational study of patients undergoing PICC insertion at the Fundación Cardioinfantil-Instituto de Cardiología (Bogotá, Colombia) during the period from 2019 to 2020 by the VA program was performed. All of the PICCs placed during the time period the study took place were either manufactured by Arrow or BD; however, no funding was received by either manufacturer for the development of this study.

Population and sample

Selection criteria:

1. Inclusion criteria
 - a. The study population was patients over 18 years of age who underwent PICC insertion by the VAs program. Medical records were reviewed for the presence of fever ($>37.8^{\circ}\text{C}$, oral cavity) or the need for antibiotic therapy up to 7 days prior to PICC insertion. Subsequently, a follow-up was performed to identify the presence of complications during the procedure and up to 1 month after the procedure.
2. Exclusion criteria.
 - a. Patients who do not have the necessary clinical records registered in the “Servinte Clinical Suite™” system.

Measuring tools

1. *Quality control of collected data:* All data were collected from the patient's clinical history by research staff other than the authors, who were responsible for entering the data into the database under confidentiality criteria. A data collection audit was performed by one of the main authors to assess the quality of data collection.
2. Bias control (selection, confounding, and other): Potential measures of bias for this study were as follows:
 - a. *Information bias:* Patients who had undergone PICC insertion at the Fundación Cardioinfantil, and consulted another care center for identification and management of complications, were excluded; it was not possible for the investigators to obtain medical reports thus incurring in loss of information.

Statistical data analysis

After data collection, a thorough review of the recorded information was conducted to avoid inconsistencies or duplications through data analysis. IBM® SPSS® Statistics was used to perform an exploratory data analysis to assess the distribution type and the presence of outliers. Subsequently, the mean and standard deviation of the evaluated variables were calculated for each year, establishing the rates of bacteremia for each period. Finally, association measures such as prevalence odds ratio (POR) were used in the defined subgroups.

Results

In all, 300 PICC placements by the VA program were registered, 157 in 2019 and 143 in 2020, with a mean age of 59 and 60 years, respectively. Similarly, homogeneous distributions are presented in terms of gender; as well as in the number of puncture attempts per procedure which was similar in both years (1.25 ± 0.6). It was found that the location of the selected patients was recorded in the intensive care unit (ICU), ambulatory, and hospitalization, the latter being the most frequent. The puncture site revealed that the basilic vein was the most used access in both 2019 and 2020 with 82.1% and 67.1%, respectively (Table 2).

Likewise, when identifying the complications related to the procedure, it was found that hemorrhage at the site of the procedure was the most prevalent with 24 cases in 2019 and 10 cases in 2020; no cases of vascular injury were registered. When evaluating the complications presented after the procedure, it was found that the most frequent in 2019 was phlebitis at 5.1%, followed by bacteremia and catheter-associated infection with 4.5%, continuing with occlusion at 3.2%, accidental displacement 2.5%, hemorrhage at the procedure

site 1.9%, and infection before 72h with 0.3%. When describing the complication-free days, in 2019 they were 22.96 (± 39.1) and 8.81 (± 10.2) in 2020. During this latter year, the causes of early complications were accidental displacement, occlusion, and bacteremia.

The bacteremia rate or central line-associated bloodstream infection (CLABSI) recorded for 2019 was 1.94 bacteremias/1000 catheter-days compared to 0.29 bacteremias/1000 catheter-days in 2020; similarly, multipuncture was registered in 5.7% of the procedures made in 2019 and 7.0% in 2020. When the subgroup analysis was performed, the multipuncture variable was evaluated in search of a correlation with the outcomes of any complication, as well as complications during and after the procedure. It was observed that the risk prevalence (POR) of any complication was 1.59 (95% CI: 0.64–4.02) times higher in the presence of multipuncture. Also, the results show that the post-procedure complications were 1.51 (95% CI: 0.42–5.48) times higher in this same group. Paradoxically, the complications during the procedure were 0.91 (95% CI: 0.20–4.15) times lower in the multipuncture group (Table 3).

Finally, the subgroup of patients who presented complications related to infection (bacteremia, phlebitis, and catheter-associated infection) was linked, evaluating their outcomes of PICC removal, as well as factors of ICU and hospital stay. It was identified that the POR for catheter removal was 13.01 (95% CI: 7.19–23.55) times higher when there was a complication associated with infection. Also, in the presence of any complication associated with infections, this group had 1.19 (95% CI: 0.15–9.52) times longer hospital stay (Table 3).

Discussion

In general terms, the sample collected was similar to the average reported in similar studies.^{12,21} Regarding the puncture location, the basilic vein access was the most frequent, which is comparable with the literature found.^{18,22} The number of puncture attempts recorded for both years was 1.25 (± 0.6) per PICC placed, this could be related to training and the use of ultrasound guidance.^{13,15,16,23} It should be noted that the complication-free days in 2019 were in accordance with the average reported in global literature; however, the results in 2020 show a lower number of complication-free days.^{12,24,25} The number of complication-free days was lower in 2020, potentially due to early complications such as accidental displacement, occlusion, and bacteremia. Early detection and management of these complications are crucial for patient safety.

Global and specific complications decreased significantly from 2019. Hemorrhage at the puncture site was the most common complication, but its incidence has not been reported.^{11,12,17–22} Bacteremia was the most frequent post-procedure complication. When analyzing the data, there was a substantial decrease from 2019 to the following year; and when compared to the frequency reported in national and

Table 2. Sociodemographic features and frequency of complications in patients with PICC placement.

	2019 <i>n</i> = 157	2020 <i>n</i> = 143
Age mean (ds)	59 (\pm 19)	60 (\pm 20)
Number of puncture attempts mean (ds)	1.25 (\pm 0.6)	1.25 (\pm 0.5)
Free days of average complication (ds)	22.96 (\pm 39.1)	8.81 (\pm 10.2)
Gender <i>n</i> (%)		
Women	81 (51.6%)	74 (51.7%)
Patient location <i>n</i> (%)		
ICU	16 (10.2%)	4 (2.8%)
In-patient	139 (88.5%)	139 (97.2%)
Out-patient	2 (1.3%)	0 (0%)
Access side <i>n</i> (%)		
Right	87 (55.4%)	68 (47.6%)
Left	70 (44.6%)	75 (52.4%)
Anatomical access site <i>n</i> (%)		
Basilic vein	129 (82.1%)	96 (67.1%)
Brachial vein	22 (14.1%)	45 (31.5%)
Cephalic vein	6 (3.8%)	2 (1.4%)
Complications during the procedure		
Hemorrhage at the procedure site <i>n</i> (%)	24 (15.3%)	10 (7.0%)
Vascular injury <i>n</i> (%)	0 (0%)	0 (0%)
Complications after the procedure		
Bacteremia <i>n</i> (%)	7 (4.5%)	1 (0.7%)
Phlebitis <i>n</i> (%)	8 (5.1%)	2 (1.4%)
Venous thrombosis <i>n</i> (%)	0 (0%)	1 (0.7%)
Embolization <i>n</i> (%)	0 (0%)	0 (0%)
Occlusion <i>n</i> (%)	5 (3.2%)	3 (2.1%)
Port fracture <i>n</i> (%)	0 (0%)	0 (0%)
Catheter rupture <i>n</i> (%)	0 (0%)	1 (0.7%)
Accidental displacement <i>n</i> (%)	4 (2.5%)	4 (2.8)
Hemorrhage at the procedure site <i>n</i> (%)	3 (1.9%)	2 (1.4%)
Central line-associated bloodstream infection (CLABSI) <i>n</i> (%)	7 (4.5%)	0 (0%)
Infection before 72h <i>n</i> (%)	1 (0.3%)	0 (0%)
Multipunction ¹ <i>n</i> (%)	9 (5.7%)	10 (7.0%)

PICC: peripherally inserted central catheter.

¹Multipunction: >2 punctions during the procedure.

Table 3. Risk prevalence by subgroups.

	POR	95% CI
Multifunction subgroup		
Any complication	1.59	0.64–4.02
Complications during the procedure	0.91	0.20–4.15
Complications after the procedure	1.51	0.42–5.48
Infection-related complication subgroup		
PICC removal	13.01	7.19–23.55
ICU stay	0.93	0.12–7.42
Hospital stay	1.19	0.15–9.52

POR: prevalence odds ratio; CI: confidence interval; PICC: peripherally inserted central catheter.

worldwide literature, these results range from 4% to 10%, which are found to be greater than the average reported in this study.^{17–19,22} The CLABSI recorded for the year 2020

revealed a decrease with respect to the previous year, placing the latter at 0.29 bacteremias/1000 catheter-days. These findings, regarding bacteremia complication rates, are comparable to what is accepted by experienced institutions.^{17,23,24,26}

When evaluating other less frequent complications, such as phlebitis, occlusion, hemorrhage at the procedure site, as well as venous thrombosis, a reduction in their frequency from 2019 to 2020 was identified. There are fewer presentations of venous thrombosis cases than what is reported in the literature, between 2.49% and 4.89%.¹⁷ In relation to this event, the institution in which the study took place does not have policies of prophylaxis with anticoagulants, as it has been stipulated in meta-analysis and related guidelines.^{25,27}

When evaluating another group of patients with only infectious complications (bacteremia, phlebitis, and catheter-associated infection), it was found that the risk prevalence of catheter removal was 13.01 times higher in these

patients with a significant 95% CI. This reflects a high adherence to the recommendations made in the literature regarding catheter salvage strategies, which have become increasingly selective given the high mortality rate in this subgroup.^{17,27} It should be noted that when relating this subgroup to their hospital stay (ICU, in-patient), the risk prevalence, although slightly higher, was not statistically significant due to the low number of cases.

In the subgroup analysis (Table 3), when evaluating the multipuncture group, the POR for presenting any complication was 1.59, and the PORs for complications during and after the procedure were 0.91 and 1.51, respectively. These findings could imply that the group exposed to multipuncture presents a greater rate of complication; however, the 95% CI is not statistically significant. This finding of a strong correlation between multipuncture and complications²⁵ has not been fully described, in this study, perhaps these associations are due to a small sample size of the multipuncture sample size. The main intention of the study was to describe the complications of PICC placement and maintenance, based on the experience of a VA group. The authors bring light to some important aspects of the subgroup analysis that can guide the scientific community in future studies and further study the causal relation between variables. The authors believe that the multipuncture variable needs further investigation, and the development of a more sophisticated methodology may provide evidence of a causal association between multipuncture and complications related to the insertion of PICC.

Limitations

The main limitations of the present study are related to the absence of pre-implementation data for the VA group. There were only bacteremia rates for previous years, which restricts the author's ability to perform subgroup analysis. In addition, the study has inherent limitations concerning causal association. Nevertheless, the authors view these limitations as opportunities for future investigations.

Conclusions

Since the inception of the VA group, an improvement has been noted in all the indicators for measuring negative outcomes due to PICC placement and maintenance. It is believed that part of the success lies mainly in the creation of a specialized group dedicated to the placement and maintenance of catheters, the use of ultrasound and ECG guidance, among others. Major positive impacts have been described regarding the complications related to PICC placement and maintenance between the 2 years this study evaluated. This is best seen in the number of free days of average complications from 1 year to another. The evidence found in the literature, regarding the possible impact that the implementation of VA programs has on PICC complications, are in alignment with the descriptions made in this study.^{14,28}

Despite the promising results, there is still room for improvement. The study observed a lower number of complication-free days in 2020 compared to the previous year, potentially due to early complications such as accidental displacement, occlusion, and bacteremia. On the other hand, global and specific complications decreased significantly from 2019 to 2020. Notably, bacteremia, a common post-procedure complication, showed a substantial decrease in frequency compared to national and worldwide literature. This suggests that the institution's practices may be effective in reducing complications, although the present study fulfills the proposed objective, it is necessary to perform studies with better scientific evidence to elucidate the factors attributable to certain complications that have not yet been clarified. However, there is a growing volume of clinical evidence that continues to demonstrate the benefits of a dedicated VA team to provide high-quality VA care, reduce associated complications, and improve patient safety.

Acknowledgements

The authors are grateful for the continued support of the VAs group at La Cardio and their comments and editorial suggestions. Notably, the authors wish to clarify that there exist no conflicts of interest, whether financial or non-financial, pertaining to this work. This assertion reinforces the unbiased nature and objectivity maintained throughout the research process.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The authors declare that no external funding was received for the conduction of this study. The resources utilized for the research were solely derived from the personal resources of the investigation group in general surgery from La Cardio.

Ethical approval

The Fundación Cardioinfantil-LaCardio Institutional Ethics Committee has approved this study (Ref. Number: 42-2020) and agreed to publish it. The study has been conducted within the guidelines of the ethical principles for medical research according to the declaration of Helsinki-59th General Assembly, Seoul, Korea, October 2008. The CIOMS guidelines, Good Clinical Practice Guidelines of the International Conference on Harmonization, and national ethical disclosures were taken into account. The investigators were responsible for maintaining the confidentiality of the information registered in medical records and the proper professional, institutional name was preserved. According to the Colombian Ministry of Health and Public Protection's Resolution 8430/1993, this is a no-risk study since it corresponds to an observational, retrospective study with no additional interventions, and all the information was collected from the patient's clinical records and underwent anonymization, and for this reason, informed consent was not required.

Informed consent

Informed consent was not sought for the present study because this is a no-risk study since it corresponds to an observational, retrospective study with no additional interventions, and all the information was collected from the patient's clinical records.

Trial registration

Not applicable.

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