ORIGINAL ARTICLE

INSERTION AND MANAGEMENT OF PERIPHERALLY INSERTED CENTRAL CATHETER IN HIGH-RISK NEWBORNS

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Highlight: (1) PICC had an average dwell time of 10 days. (2) Central catheters had fewer complications. (3) The most frequent complications were infection, obstruction, and infiltration.

PRE-PROOF
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ABSTRACT

The objective of this study was to analyze data on the insertion and management of peripherally inserted central catheters (PICC) in high-risk newborns admitted to a Neonatal Intensive Care Unit (NICU). This is a retrospective documentary study that included 333 PICC insertions in 204 high-risk newborns admitted to a reference NICU in the Ditrito Federal, Brazil, during the

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year 2022. Data were collected using a standardized form implemented by the institution's Hospital Infection Control Committee and supplemented by consultation of the patient's electronic medical records. The research was submitted to the Research Ethics Committee and approved in 2022. The sample showed a slight predominance of females, with the majority of patients being premature and having an appropriate birth weight for gestational age. The average number of punctures was 2.44 (± 1.68). The mean dwell time was 10.65 (± 7.13) days. Older patients underwent more puncture attempts, as well as those with a higher weight at insertion. Central catheters had a longer dwell time and fewer complications. The most prevalent complications were infection, obstruction, and infiltration, with some of them leading to unscheduled removal of the device. The findings are consistent with current literature and highlight the importance of proper training for the nursing team in the insertion and management of the device.

Keywords: Newborn; Neonatal nursing; Peripheral catheterization; Central venous catheterization.

INTRODUCTION

The intravenous route is the primary access used in the treatment of high-risk newborns, who often require prolonged treatment in the Neonatal Intensive Care Unit (NICU). Irritating and vesicant solutions to peripheral vessels, such as vasoactive drugs, parenteral nutrition, blood transfusions, and antibiotic therapy, are frequently used[1-2].

In this context, the peripherally inserted central catheter (PICC) appears as a safe and efficient device, having been used in the treatment of newborns for over 40 years and in Brazil since the year 2000[3]. It is a long, flexible, radiopaque catheter made from biocompatible materials (typically silicone or polyurethane); it can be single-lumen or double-lumen and has a central position, as it is inserted into a peripheral vein (commonly the basilic, brachial, cephalic, and saphenous veins) and migrates to the proximal region of the superior or inferior vena cava[4-6]. Confirmation of catheter positioning is performed using ultrasonography, electrocardiogram, and chest X-ray, with chest X-ray being the most commonly used technology for tip verification[7].

The Conselho Federal de Enfermagem (Brazil's Federal Nursing Council) has regulated the insertion and management of the PICC by nurses since 2001, with the most recent updated version being Resolution nº 243/2017, which reaffirms the technical and legal competence of this professional, further validating their importance in newborn care[8].

PICC offers advantages such as being able to be inserted at the bedside, reducing the newborn's exposure to multiple venous punctures, preserving the patient's vessels, and providing a safe route for administering vesicant and irritating medications. It is associated with a lower risk of infection and less discomfort for the newborn, as it reduces exposure to painful procedures, stress, and handling. Furthermore, since it is inserted through a peripheral route, it reduces the incidence of complications and iatrogenesis, such as pneumothorax and hemothorax[3,5].

Despite the advantages of using the PICC, it is necessary for professionals to remain alert to the risks related to the device. Venous access puncture is particularly challenging in the neonatal population, as the small-caliber vessels present greater difficulty in venous cannulation[9].

Intercurrences and complications can occur at the time of insertion, during maintenance, or even during catheter removal. Among the complications observed are obstruction, catheter rupture, vein perforation, extravasation, thrombus formation, infection, catheter-associated sepsis, hematomas, and incorrect positioning[10-11]. Anatomical alterations such as stenosis, thrombosis, or lesions compressing the vessels complicate the proper positioning of the PICC. Consequently, improper positioning is approximately three times more frequent with the PICC than with other central access devices, and this factor influences the occurrence of other complications, such as extravasation, infiltration, and thrombosis[7].

Given the above, the objective of this study was to analyze the data on the insertion and management of peripherally inserted central catheters (PICC) in high-risk newborns admitted to the Neonatal Intensive Care Unit (NICU).

MATERIALS AND METHODS

This is a documentary and retrospective study conducted with data from newborns admitted to the NICU of a reference hospital for high-risk maternal and child care in Brasília –

DF, Brazil. The choice of this setting is justified by the institution's recognition as a neonatal care reference, being the one with the most NICU beds in the state, with advanced infrastructure and technology, and using the PICC as the first-choice catheter after the removal of the umbilical catheter. Additionally, it has a team of qualified and trained nurses to perform the procedure.

The sample included all medical records of newborns admitted to the NICU who underwent PICC insertion in 2022. Newborns who had the catheter inserted in another unit, incomplete procedure data recorded in the medical record, PICC insertion performed by a medical professional, and those who were transferred to another institution before catheter removal were excluded from the study. The total sample consisted of 333 PICC insertions in 204 patients, with 303 insertions included in the analysis of this study and 30 excluded. Procedures performed during the year 2022 were analyzed, and data collection was carried out between November 2022 and April 2023.

For data collection, a standardized form from the institution's Hospital Infection Control Committee, titled "Surveillance Form – NICU," which describes the devices used in the NICU, was used. Information from this list was supplemented by consulting the newborns' electronic medical records.

The following variables related to the newborns were collected: sex, gestational age at birth, classification according to birth weight, chronological age, and weight at the time of insertion. Variables related to insertion and removal of the device included: indication, vein punctured, number of puncture attempts, positioning, need for traction, presence of complications, and reason for catheter removal. Data organization was carried out through tables using Excel® 2016, and statistical analysis was performed using the R® 4.2 Program.

For quantitative variables such as gestational age, chronological age at the time of puncture, birth weight, weight at the time of catheter insertion, number of puncture attempts, and catheter dwell time in days, descriptive statistics (mean and standard deviation) were used. For qualitative (or categorical) variables, such as sex, vein punctured for PICC insertion, positioning after X-ray, need for catheter traction after X-ray, reason for catheter removal, frequency distributions were used.

To verify interactions between gestational age and puncture attempts; weight at insertion and vein punctured; vein punctured and catheter dwell time, number of attempts and reason for removal, the Kruskal-Wallis test was used. To verify associations between chronological age in days and puncture attempts; weight at insertion and puncture attempts; puncture attempts and catheter dwell time, Spearman's correlation test was used. For testing interactions between gestational age and positioning; gestational age and vein punctured; chronological age and vein punctured; classification according to birth weight, gestational age, and vein punctured; vein punctured and positioning; vein punctured and need for traction; positioning and reason for removal; vein punctured and reason for removal, the Chi-square test was used. For chronological age and positioning; weight at insertion and positioning; number of attempts and positioning; positioning and catheter dwell time, the Mann-Whitney test was performed.

The research was submitted to the Comitê de Ética em Pesquisa da Fundação de Ensino e Pesquisa em Ciências da Saúde (Ethics Committee of the Foundation for Teaching and Research in Health Sciences) (FEPECS/SES/DF) and approved with approval number 5.556.781.

RESULTADOS

As described in Table 1, in this study, 51.96% (n=106) of the patients are female, while 48.04% (n=98) are male. Regarding gestational age at birth, 81.38% (n=98) are preterm, with nearly half, 40.69% (n=83) being moderately preterm. There was no sample related to post-term neonates in this study. Regarding birth weight appropriate for gestational age, 75% (n=153) of the patients had weight appropriate for gestational age at birth, and only 2.94% (n=6) were large for gestational age. The chronological age at the time of insertion ranged from 1 to 119 days of life, with a mean of 18.57 (± 23.96).

Table 1 – Characterization of Newborns – Brasília, DF, Brazil, 2023.

	N	%
Sex		
Female	106	51,96
Male	98	48,04
Gestational age at birth		
Extreme preterm (less than 28 weeks)	47	23,04
Moderate preterm (28 to 33 weeks and 6 days)	83	40,69
Late preterm (34 to 36 weeks and 6 days)	36	17,65
Term (37 to 41 weeks and 6 days)	38	18,63
Classification according to birth weight and gestational age		
Appropriate for gestational age (AGA)	153	75,00
Small for gestational age (SGA)	45	22,06
Large for gestational age (LGA)	6	2,94

Source: Author's own elaboration.

As shown in Table 2, the most prevalent indication for catheter insertion was the use of parenteral nutrition, with 52.94% (n=108), followed by antibiotic therapy with 30.88% (n=63), and the use of vasopressor drugs with 9.80% (n=20). The most frequently catheterized vein was the basilic vein, with 16.17% (n=49), followed by the cephalic vein with 11.55% (n=35) and the antecubital vein with 10.89% (n=33). It is important to note that 22.44% (n=68) of the records did not contain information regarding the punctured vein.

Regarding positioning, 88.78% (n=269) of the PICCs were positioned centrally, with 54.13% (n=164) of the catheters requiring traction after the chest X-ray. Complications resulting from the use of PICC included infection, with 15.84% (n=48), obstruction with 10.56% (n=32), infiltration with 5.28% (n=16), catheter rupture with 5.28% (n=16), and phlebitis with 0.99% (n=3). No cases of thrombosis associated with the use of PICC were recorded in the evaluated sample. Not all complications led to device removal, but almost half of the catheters, 48.19% (n=146), were removed due to complications, 41.58% (n=126) due to the completion of intravenous therapy, and 10.23% (n=31) due to patient death.

Table 2 – Distribution of variables related to the catheter – Brasília, DF, Brazil, 2023.

	N	%
Indication		
Antibiotic therapy	63	30,88
Parenteral nutrition	108	52,94
Vasopressor drugs	20	9,80
Intravenous hydration	8	3,92
Analgesia	5	2,45
Punctured vein		
Basilic	49	16,17
Brachial	3	0,99
Axillary	12	3,96
External jugular	15	4,95
Temporal	30	9,90
Cephalic	35	11,55
Dorsum of the hand	15	4,95
Retroauricular	3	0,99
Saphenous	21	6,93
Antecubital	33	10,89
Femoral	4	1,32
Radial	14	4,62
Posterior tibial	1	0,33
No information recorded	68	22,44
Complications		
Infection	48	15,84
Accidental traction/displacement	15	4,95
Catheter rupture	16	5,28
Obstruction	32	10,56
Phlebitis	3	0,99
Infiltration	16	5,28
Hematoma	3	0,99
Improper positioning	16	5,28

Source: Author's own elaboration.

The number of puncture attempts ranged from 1 to 9, with an average of 2.44 (± 1.68). In this study, the Kruskal-Wallis test was used to assess whether there was an association between the number of puncture attempts and gestational age, and the p-value indicated no difference in the mean number of puncture attempts by gestational age. However, applying the Spearman Correlation test showed that older newborns in chronological age underwent more

puncture attempts. The number of puncture attempts was not related to catheter positioning, duration of use, or reason for catheter removal.

The catheter dwell time ranged from 0 (when the catheter was removed before 24 hours after insertion) to 38 days, with an average of 10.65 (± 7.13) days.

The Chi-square test revealed that gestational age influences the punctured vein. In extreme preterm patients, the most commonly punctured vein was the antecubital vein (4.6%, n=14). In moderate preterm patients, the basilic vein (8.9%, n=29) was most commonly punctured. In late preterm patients, the temporal vein (3.3%, n=10) was the most frequently punctured. Finally, in term newborns, the basilic vein (2.3%, n=7) was the most punctured.

This study did not find an association between the punctured vein and catheter positioning. The punctured vein was not related to the need for catheter traction or the duration of catheter use.

The newborn's weight at the time of catheter insertion ranged from 570 to 4255 grams, with an average of 1689.11 (± 796.95) grams. The Spearman Correlation test showed an association between the newborn's weight at insertion and the number of puncture attempts, with heavier newborns being punctured more often. Moreover, in newborns with higher weight at insertion, the most punctured veins were the retroauricular, axillary, and external jugular veins.

Finally, positioning influenced catheter dwell time (according to the Mann-Whitney test) and the reason for catheter removal (according to the Chi-square test). The average dwell time for centrally positioned catheters was 11.29 (± 7.02) days, compared to 5.59 (± 6.01) days for peripheral catheters. Of the centrally positioned catheters, 39.6% (n=120) were removed due to the completion of venous therapy, while only 1.98% (n=6) of peripheral catheters were removed for the same reason. Of the centrally positioned catheters at the time of insertion, 2.97% (n=9) were removed due to infiltration, whereas 2.31% (n=7) of peripheral catheters were removed for the same reason. It is important to note that positioning was assessed immediately after insertion, and it is possible that centrally positioned catheters developed infiltration after displacement and accidental traction.

DISCUSSION

This study observed a slight predominance of female neonates, as in a retrospective correlational study conducted in a University Hospital evaluating nursing practices in PICC insertion, maintenance, and removal in neonates found that 51.1% (n = 70) of the patients were female[11]. Another retrospective study conducted in a NICU in the southern region of Brazil which aimed to identify the main factors for PICC removal in newborns also found that 50.3% (n = 370) of the sample was female[12]. Additionally, Silveira and collaborators carried out an exploratory study that had the following objectives: to characterize newborns who used PICC in the NICU, to identify complications arising from the use of the device in this population and to analyze the factors that may be associated with such complications. Of the sample of 111 newborns, 55% (n= 61) were male, different from what was found in the current study[13].

Regarding the population of this study, the majority (81.38%, n= 265) were preterm. Integrative review of the literature aimed to understand the publications on the profile of newborns admitted to the NICU in the last 10 years and points out that the main reason for needing admission to the NICU is premature birth, which would justify the sample found[14]. Even so, in the cross-sectional study carried out by Sousa and collaborators that evaluated the main nursing diagnoses carried out in the care of newborns hospitalized in two NICUs of a reference maternity hospital, newborns classified as moderately preterm represented 40.9% (n= 63) of the sample, as found in this study (40.69%, n= 83) [15]. In the controlled clinical trial carried out with 46 newborns that aimed to compare the PICC with cut and uncut length adjustment, newborns between 29 and 36 weeks represented the majority of the sample, similar to what was found in this research[16]. Regarding the classification of birth weight in relation to gestational age, in the previously reported study carried out in Espírito Santo, Brazil, 67.9% were classified as AGA, 31.4% as SGA and 0.7% as LGA, similar to what was found in the sample of this study[11]. In a retrospective cohort study that analyzed 401 PICC insertions to identify risk factors for PICC-associated bloodstream infection in newborns, AGA also represented the majority of the sample (71.3%)[17].

A randomized clinical trial carried out with 88 newborns with the objective of analyzing the results of PICC insertion procedures used two measurement methods and obtained similar results regarding the indication of PICC, with the need for administration of parenteral nutrition

58.0% (n=51), antibiotics 28.4% (n= 25) and vasoactive drugs 13.6% (n= 12) being the most prevalent[18]. Carneiro and collaborators carried out a documentary, descriptive, retrospective study with the objective of evaluating the use of peripherally inserted central catheters in terms of the newborn's profile, indications for use and catheterized vein; relationship between the number of puncture and vein attempts, and assessment of the positioning of the catheter tip[19]. In it, the most prevalent indication was antibiotic therapy (53.8%), followed by parenteral nutrition (32.6%). Preterm newborns have immature systems, organs and devices, in addition to having little energy reserves; These factors result in food intolerance and the impossibility of using the enteral route exclusively, especially in the first weeks of life, which justifies the use of parenteral nutrition on a large scale[20]. Furthermore, the immaturity of the immune system can make the newborn more susceptible to infections, which explains the use of antibiotic therapy[14].

The possibilities for PICC puncture sites are extensive, especially in neonatology. The catheter can be inserted through puncture of the basilic, cephalic, brachial, median cubital or external jugular veins in patients of all ages. In newborns, in addition to the aforementioned vessels, there is the possibility of puncturing the metacarpal, temporal, posterior auricular, axillary, saphenous and popliteal veins[21]. The vessels most punctured in the sample of this study are compatible with what is found in current literature[1, 11-12, 19, 22]. Puncture in the upper limbs, especially the basilic and cephalic veins, is preferable due to easy access, fewer valves and larger caliber[11]. The use of other vein options is probably associated with the prolonged hospital stay of newborns, multiple punctures and the need for more than one catheter during the period they are hospitalized[19].

In the current study, there was no association between punctured vein and positioning, unlike a retrospective analysis that aimed to evaluate catheter duration, the incidence of non-elective removal and complication rates associated with PICC in relation to different catheter positions in extremely preterm infants, in which catheters inserted into the veins of the lower limbs were associated with central positioning[23].

An observational and descriptive study aimed to outline the profile of PICC use in the healthcare reality of the NICU. It demonstrated that, when the catheter is inserted in the first days of life, the procedure is easier and reduces the number of punctures to which the newborn

is subjected due to the preservation of the venous network, which could justify what was found in this study, in which newborns with more days of life were punctured more to obtain successful insertion of the device[24].

Regarding the number of puncture attempts, the average obtained in this study is similar to that seen in the literature[11, 19, 22]. However, some newborns underwent multiple attempts, reaching 9 punctions. It is important to emphasize that the number of attempts recommended by professionals is limited to two, and multiple attempts lead to an increased risk of infection and pain[11]. The increased number of punctures in older newborns is possibly associated with a less preserved venous network[22]. Unlike what was found in the current study, a retrospective descriptive study that analyzed 195 medical records of newborns who underwent PICC insertion observed that the number of puncture attempts was higher in patients with lower weight at insertion[25].

The catheter retention time was similar to that found in the literature. Brazilian studies conducted in NICUs cited above presented an average of 10.6 (± 7.13) and 12.6 days (± 18.57), while in the current study the average was 10.65 (± 6.3) [1,11].

Regarding location, it is important that the catheter is properly positioned to avoid vascular injuries and complications arising from the administration of vesicant and irritant medications at a peripheral site[26]. The predominant positioning in this study was central, as in recent studies[18-19,22]. Also in line with the current literature, positioning interfered with the reason for catheter removal, in which devices with proper positioning resulted in greater durability and success rates, reflected by the scheduled removal of the device[11-12,19].

More than half of the PICCs evaluated in this study required traction, which is a common occurrence observed in several other studies[1,11,22]. In the clinical trial conducted by Tomazoni and collaborators mentioned above, most of the catheters in the control group were in an intracardiac position and needed to be tractioned[18]. Even in the experimental group, almost half of the catheters were inside the heart. The conventional measurement technique to avoid inadequate positioning of the PICC is the anatomical measurement of the venous path from the puncture site to the central region. This measurement is equivalent to the length of the catheter that will be inserted. However, newborns have different locations of the venous network and anatomical landmarks compared to adults, which makes ideal positioning a challenge[18]. As

pointed out by Beleza and collaborators, recent studies have proposed formulas to aid in measuring the catheter, with the aim of making it more assertive[27]. One study considered the weight and height of newborns and estimated different formulas according to the puncture site[6]. The second assigned a constant value according to the vein to be punctured, weight range and birth weight[2]. Both studies presented safe alternatives in relation to conventional measurement and provided greater comfort for the newborn by reducing the need for traction and, consequently, for new dressing[27].

In this study, the occurrence of complications was similar to that found in the literature, which ranges from 30.7% to 62.2%[11]. In the study by Silveira cited above, carried out in a public hospital in Minas Gerais, Brazil, the occurrence of complications was 51%, with the most frequent being inadequate positioning (25.7%), phlebitis (19.3%) and occlusion (3.7%)[13]. However, in a cross-sectional study that sought to identify the determining factors for non-elective PICC removal in newborns admitted to the NICU, the occurrence was 41.66%, with the most frequent being infiltration (12.03%), accidental traction (11.11%) and external rupture (9.25%)[1].

The high frequency of infection can be explained by both the immaturity of the newborn's immune system and care failures that cause catheter-associated bloodstream infection[28]. This is a common complication that increases costs and suffering for the mother and newborn, in addition to increasing morbidity and mortality[17]. Obstruction occurs due to the presence of clots or fibrin in the lumen or tip of the catheter, caused by inadequate catheter washing or blood reflux. To maintain catheter permeability, frequent washing with saline solution is important, as well as contraindicating the administration of medications that crystallize (such as Phenytoin and Diazepam) and the infusion of hemoconcentrates[13]. Infiltration, in turn, is almost always associated with inadequate (peripheral) positioning, and identifying this factor may be able to prevent infiltration[1]. In this study, accidental traction and rupture of the catheter occurred at frequencies similar to those found in the literature[1,4,12]. It is important to emphasize that catheter rupture may be associated with inadequate handling by the nursing team, due to the use of higher pressures than indicated[29]. Phlebitis was the least frequent complication – 1%; phlebitis consists of inflammation of the vessel walls due to chemical,

mechanical or infectious factors and occurred below the incidence addressed in the literature[11,13,30].

Ideally, the catheter should be removed in a scheduled manner, at the end of the patient's intravenous therapy. The result found in this study is similar to that indicated in the literature, in which almost half of the catheters are removed non-electively[1,11,18,22].

The presence of complications may reflect care practices that do not comply with the recommendations for handling the catheter. Nursing care is essential for maintaining the device. Health education, such as training the team to identify complications related to failures in care, is essential to ensure the maintenance of a safe, long-lasting and painless vascular device. This is one of the greatest challenges for those who care for high-risk newborns, since they require prolonged venous therapy[19,29].

CONCLUSION

The peripheral insertion central venous catheter is essential for the proper care of high-risk neonates, who often require intensive care unit attention. It is a safe device capable of providing an adequate venous route for an extended period and is increasingly used in neonatology. It reduces pain and the number of procedures the neonate undergoes, minimizing stress and manipulation.

This study analyzed the practices of insertion and maintenance of PICCs in an ICU in Distrito Federal, Brazil, in 2022. Through this analysis, it was possible to describe the characteristics of the neonates who underwent catheter insertion, as well as verify the characteristics of the device in the procedure of insertion, maintenance, and removal. Associations were also found that show the characteristics of the neonates may be related to the dynamics of the insertion procedure, as well as the insertion dynamics being related to the duration of the device. The results obtained were similar to the available literature.

Despite the advantages offered by the use of the PICC, it is not without complications. The most frequent complications in the present study were infection, obstruction, infiltration, and accidental traction. The observed incidence of complications is significant, with nearly half of the devices being removed for this reason, which is consistent with current literature.

The occurrence of complications may be associated with improper handling of the device by the healthcare team. Nursing care is essential for the maintenance of the catheter. Therefore, the importance of continuing education is highlighted, so that care is more assertive and cautious.

One of the limitations of the study was the lack of complete information in the instrument used at the institution and in the patient's electronic medical record, leading to the need to exclude some insertions and the incomplete filling of information for others.

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INSERTION AND MANAGEMENT OF PERIPHERALLY INSERTED CENTRAL CATHETER IN HIGH-RISK NEWBORNS

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