Cogitare Enfermagem

ORIGINAL ARTICLE

# Effectiveness of techniques for repositioning peripherally inserted central catheters in newborns

## HIGHLIGHTS

1. Reduces exposure to new procedures.
2. May help reduce complications.
3. Premature patients benefit from these techniques.
4. Catheter tips in large vessels are easier to reposition.

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## ABSTRACT

**Objective:** To evaluate the effectiveness of techniques for repositioning peripheral insertion central catheters in newborns. **Method:** A quasi-experimental study was conducted in a Neonatal Intensive Care Unit at a hospital in southern Brazil between June and September 2023, involving 32 catheters. Combined repositioning techniques were applied, depending on the location of the catheter: traction, elevation of the decubitus position, rapid infusion of saline solution, movement of the upper limbs, and neck. Descriptive analysis was used. The technique was effective when the catheter moved to the cavoatrial junction. **Results:** Intracardiac and contralateral subclavian catheter positions were predominant. In 24 cases, the techniques were effective on the first attempt at repositioning; in six cases, the catheters migrated to the cavoatrial junction after the second maneuver; and in two cases, the techniques were not effective. **Conclusion:** Catheters with tips in large vessels were successfully repositioned; for those that were angulated or coiled in smaller veins, the maneuvers were less effective.

**DESCRIPTORS:** Newborn; Catheters; Central Venous Catheterization; Vascular Access Devices; Neonatal Intensive Care.

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## INTRODUCTION

The Peripherally Inserted Central Catheter (PICC) is a central venous access obtained from peripheral or deep puncture of the venous network, whose catheter migrates through the anatomical flow to the lower third of the superior vena cava or to the Cavo-Atrial Junction (CAJ)[1].

Used in Neonatal Intensive Care Units (NICUs) as a long-term venous access, the PICC has the following indications: antibiotic therapy or infusion solutions for seven days or more, vesicant or irritating solutions (extreme pHs), hyperosmolar solutions (greater than 900mOsm/L) and vasoactive drugs,[1] in addition to preservation of the venous network, given the reduction in peripheral punctures[2].

Despite its advantages, the use of PICC is not without local complications such as phlebitis, infection, and thrombosis, as well as systemic complications such as septicemia and pulmonary embolism. In addition, circumstantial complications may occur during its stay, such as obstruction, rupture, difficulty in removing the catheter, and poor tip positioning when the PICC is located outside the CAJ[2-3].

The off-center location of the tip may prevent or limit its use, given the possibility of the tip lodging in peripheral vessels or cardiac chambers, with a high risk of extravasation, arrhythmias, hypotension, increased central venous pressure, and cardiac tamponade. When malpositioning is identified, nurses must use resources to ensure continuity of care for the newborn and make assertive decisions on how to manage it, optimizing the insertion already performed and reducing the need for new procedures in the newborn. Before indicating removal of the poorly positioned catheter, it is possible to use non-invasive repositioning techniques to move its tip to the CAJ or to the lower portion of the superior vena cava, if inserted in the scalp, jugular, or upper limbs, or to the upper portion of the inferior vena cava, if inserted in veins of the lower limbs.

These techniques are performed by moving the newborn's limb, infusing saline solution, manually pulling the catheter, or waiting for the catheter to migrate spontaneously with blood flow, depending on the type of location. These techniques are considered safe and important for increasing the cost-effectiveness of the insertion already performed. However, scientific evidence on the clinical application of PICC repositioning techniques, especially in the neonatal population, is limited[4].

Different techniques can be used, depending on factors such as the PICC insertion vein, the initial location of the tip, and the patient's stability. The catheter shifts to the central position due to movements within the venous system after the repositioning techniques are applied[1]. Given this, the objective of this study was to evaluate the effectiveness of PICC repositioning techniques in newborns (NBs).

## METHOD

This is a quasi-experimental study in which the intervention consisted of applying repositioning techniques according to the location of the catheter tip. The outcome was assessed by the migration of the PICC tip to the CAJ or lower portion of the superior vena cava, in cases of insertion into the scalp, jugular vein, or upper limbs, or to the upper portion of the inferior vena cava, in cases of insertion into veins of the lower limbs.

The central location of the catheter, in the anatomy mentioned, was classified according to the definition of the Infusion Nursing Society (INS)[1]. The outcome was assessed by chest X-ray imaging, and the technique was considered effective in cases where the catheter moved to the central position and ineffective when it migrated to other non-central vessels or did not move in the venous network. A limit of up to three interventions per catheter was established; in unsuccessful cases, the care team made the decision regarding care for the patient with a catheter, according to the routine already established at the research site.

Data collection took place between June and September 2023, with patients admitted to a 30-bed NICU at a university hospital in the state of Paraná. Of these, 10 beds are in the NICU, 15 beds are in the Neonatal Intermediate Care Unit (NICUco), and five beds are in the Kangaroo Neonatal Intermediate Care Unit (NICUka).

The sample was determined based on the estimated prevalence of PICC malposition in the unit, which was 33% of catheters inserted between June and September 2022, the period corresponding to data collection, as well as based on scientific literature, which reports a 25.7%[2] to 35.1% occurrence of malposition among inserted PICCs. Given this, a sample of 30 catheters was estimated.

The sample consisted of 32 patients admitted to the NICU, using 32 PICCs, who met the inclusion criterion of having a poorly positioned PICC on chest and abdominal X-ray images. The following were established as exclusion criteria: incomplete completion of the research instrument and unavailability of imaging exams.

The PICC repositioning techniques were based on scientific literature, and nurses qualified to insert the PICC were trained prior to data collection. For this purpose, a PowerPoint® presentation was used, and a practical guide containing the repositioning techniques according to the location of the catheter tip was made available in printed format and via Quick Response Code (QR Code).

At the study site, nurses used the blind direct puncture insertion technique in accordance with routine practice. The anatomical measurement for catheter insertion was taken from the puncture site to the right sternoclavicular space in the case of the upper limbs, scalp, and jugular vein. For the lower limbs, the anatomical reference was puncture site to the inguinal region, umbilical scar to the xiphoid process.

The techniques used for repositioning, depending on the location of the catheter tip, were as follows: traction of PICC with intracardiac tip, based on the assessment of chest X-ray length; elevation of the patient's head between 30°-45° for 30 minutes; rapid infusion of saline solution according to the patient's weight; abduction and adduction movements of the shoulder in which the PICC was inserted, and extension of the elbow; lateralization/extension of the neck, according to the need to mobilize the catheter for proper repositioning[5-8].

The volume of saline solution for rapid infusion was 1 mL per kilogram, as identified in the scientific literature. In addition, this volume was discussed with the coordinating physician of the NICU at the study site to ensure it was appropriate for the patients' clinical profiles. The techniques were applied individually or in combination, depending on the type of catheter malposition identified in each patient.

For data collection, an instrument was used that was designed with information about the patients' profiles, as well as variables related to the techniques to be applied, such as identification of the insertion vein, the initial and final location of the catheter tip, and the ventilation mode used by the patient.

Descriptive data analysis was performed using absolute (number) and relative (percentage) frequencies. The data were stored and analyzed using Microsoft Office Excel® spreadsheets, and the radiographic images were stored for analysis.

The outcome variable that defined the effectiveness of the techniques was the repositioning of the catheter to the CAJ or to the superior or inferior vena cava, identified by radiography performed immediately after the repositioning technique.

Regarding ethical principles, the research was conducted under Resolution No. 466, dated December 12, 2012, of the National Health Council, and approved by the institution's Research Ethics Committee (REC), having been approved under Opinion 6.159.325. The parents/guardians of hospitalized patients with poorly positioned PICC lines were invited to participate in the study, and, after acceptance, the Free and Informed Consent Term (FICT) was applied.

## RESULTS

The study sample consisted of 32 PICCs used in 32 newborns. Of these, 14 (43.7%) were moderately premature, with a gestational age of 31 to 36 weeks, 10 (31.3%) were extremely premature, born between 24 and 30 weeks, and eight (25%) were full-term. The average weight of the newborns was 1,573 grams, ranging from 540 to 4,660 grams, as shown in Table 1.

Regarding ventilatory support, most newborns used some type. Ten (31.25%) were on mechanical ventilation, 10 (31.25%) on Continuous Positive Airway Pressure Bubble (CPAP Bubble), three (9.4%) on Nasal Intermittent Positive Pressure Ventilation (NIPPV), and three (9.4%) on Continuous Positive Airway Pressure (CPAP) (Table 1).

**Table 1.** Characterization of patients with poorly positioned PICC lines. Curitiba (PR), Brazil, 2023

| Patient characteristics | n | % |
|---|---|---|
| **Classification by gestational age at birth** | | |
| Extreme premature babies | 7 | 21.9 |
| Many premature babies | 14 | 43.7 |
| Moderate premature | 3 | 9.4 |
| Full-term | 8 | 25 |
| **Birth weight** | | |
| Less than 1000g | 9 | 28.2 |
| 1000g to 1999g | 12 | 37.5 |
| 2000g to 2999g | 6 | 18.7 |
| Over 3000g | 5 | 15.6 |
| **Ventilation mode** | | |
| Mechanical ventilation | 13 | 40.6 |
| Nasal Intermittent Positive Ventilation | 3 | 9.4 |
| Continuous Positive Airway Pressure | 10 | 31.3 |
| Nasal catheter | 1 | 3.1 |
| Ambient air | 5 | 15.6 |

Source: The authors (2023).

The average length of stay at the time of catheter insertion was 9.3 days, ranging from 1 to 63 days. The indication for the PICC was predominantly the use of antibiotic therapy associated with Total Parenteral Nutrition (TPN), representing 11 (34.4%) of the participants, followed by exclusive TPN in nine (28.1%) cases and antibiotic therapy alone in nine (28.1%) of the indications, as shown in Table 2.

Regarding the catheter insertion vein, nine (28.1%) insertions were observed in the left basilic vein. Regarding poor catheter tip positioning, 18 (56.25%) were located in an intracardiac position, and four (12.5%) were in the contralateral subclavian vein (Table 2).

In 24 cases, the techniques were effective on the first attempt at repositioning; in five situations, the catheters migrated to the CAJ after the second maneuver; and in two cases, the techniques were not effective.

Repositioned with only one maneuver: the four catheters positioned in the contralateral subclavian vein, two coiled in the jugular vein, 15 intracardiac, one coiled in the axillary vein, and two coiled in the subclavian vein.

In one of the cases where the PICC tip was located in the subclavian vein, after the maneuver, it was positioned in the jugular vein due to reflux. Therefore, a new maneuver was performed, with which the catheter migrated to the CAJ. Table 1 shows the positions in which a single maneuver attempt was sufficient to reposition the catheter, while Table 2 describes the other positions and the respective maneuvers with their final outcomes.

**Table 2.** Characterization of PICC insertion. Curitiba (PR), Brazil, 2023

| Length of stay at PICC insertion | .n | % |
|---|---|---|
| 0 to 14 days | 28 | 87.5 |
| ≥15 days | 4 | 12.5 |
| **PICC insertion vein** | | |
| Right jugular | 2 | 6.3 |
| Basilica | 13 | 40.6 |
| Cephalic | 7 | 21.9 |
| Axillary | 4 | 12.6 |
| Cephalic region | 1 | 3.1 |
| Lower limbs | 5 | 15.4 |
| **Indication of PICC** | | |
| Total Parenteral Nutrition (TPN) | 9 | 28.1 |
| Antibiotics | 9 | 28.1 |
| Antibiotic and TPN | 11 | 34.4 |
| Other | 3 | 9.4 |
| **Initial location of the PICC tip** | | |
| Contralateral subclavian | 4 | 12.5 |
| Coiled in jugular | 2 | 6.3 |
| Intracardiac | 18 | 56.2 |
| Angled in axillary | 1 | 3.1 |
| Angled in jugular | 1 | 3.1 |
| Axillary coil | 3 | 9.4 |
| Subclavian coil | 2 | 6.3 |
| Subclavian | 1 | 3.1 |

Source: The authors (2023).

**Chart 1.** Initial position and maneuver relationship, with outcome for repositioning in a single attempt. Curitiba (PR), Brazil, 2023

| Initial location | Maneuvering |
|---|---|
| Contralateral subclavian (n=04) | Elevation of the headboard between 30° and 45° for 30 minutes and Rapid Infusion of Physiological Solution (RIPS) according to the patient's weight (1 mL per kilogram). |
| Angled in jugular (n=02) | Elevate the headboard between 30° and 45° and administer RIPS according to the patient's weight (1 mL per kilogram). |
| Angled in subclavian (n=02) | Elevation of the headboard between 30° and 45° for a period of 10 to 30 minutes, with abduction of the limb at the time of RIPS according to the patient's weight (1 mL per kilogram). |

Source: The authors (2023).

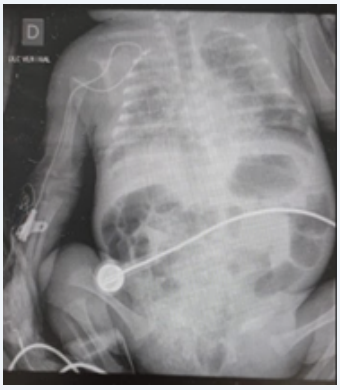
**Chart 2.** Description of maneuver according to initial location of catheter tip and final outcome. Curitiba (PR), Brazil, 2023

| Initial location | Maneuvering | Initial outcome | Final outcome |
|---|---|---|---|
| Intracardiac (n=18) | Assessment of how many centimeters exceeded the CAJ and traction performed using sterile technique. | 15 repositioned themselves in the CAJ. | After further traction, three repositioned themselves in the CAJ. |
| Angled in axillary (n=01) | Elevation of the headboard between 30° and 45°, abduction of the limb in which the PICC was inserted, lateralization of the head to the side in which the catheter was inserted (to prevent the catheter from migrating to the jugular due to reflux), and RIPS according to weight (1 mL per kilogram). | It remained angled. | After performing the same maneuver, the catheter became entangled in the subclavian artery; it was decided to remove it. |
| Angled in jugular (n=01) | Elevation of the headboard between 30° and 45°, lateralization of the head to the side opposite to that in which the PICC was inserted, and RIPS according to the patient's weight (1 mL per kilogram). | It remained angled in the jugular, with slight movement of the catheter. | After performing the same maneuver, keeping it bent in the jugular vein, it was decided to remove it. |
| Coiled in axillary (n=03) | Abduction of the shoulder on the side where the PICC was inserted, combined with elbow extension, when RIPS was performed according to the patient's weight (1 mL per kilogram). | One migrated to CAJ. | |
| | | One remained coiled in the axilla. | The same maneuver was repeated, undoing the loop, but keeping the tip of the peripheral PICC in the axilla. |
| | | One repositioned itself in the intracardiac space. | After traction, the catheter was positioned in the CAJ. |
| Angled in axillary (n=01) | Elevation of the headboard between 30° and 45°, abduct the limb in which the PICC is inserted, and administer RIPS according to the patient's weight (1 mL per kilogram). | After the maneuver, it positioned itself in the jugular vein due to reflux. | The head was turned to the opposite side of where the catheter was inserted, and RIPS was performed according to the patient's weight (1 mL per kilogram). Afterward, it was positioned in the CAJ. |

Source: The authors (2023).

Table 3 shows some of the X-ray images before and after the repositioning maneuvers.

**Chart 3.** X-ray images before and after the application of PICC tip repositioning maneuvers. Curitiba (PR), Brazil, 2023

| Location of the PICC tip before the maneuver | Maneuver applied | Location of the PICC tip after the maneuver |
|---|---|---|
|  | Initial location: rolled up in the right axilla.<br><br>Maneuver: abduction of the shoulder on the side where the PICC was inserted combined with elbow extension at the time of RIPS* administration according to the patient's weight (1 mL per kilogram). |  |
|  | Initial location: subclavian<br><br>Maneuver: elevation of the head between 30° and 45°, abduction, and RIPS.<br><br>Location after the maneuver: jugular vein due to reflux.<br><br>New positioning: jugular vein due to reflux.<br><br>Maneuver: lateralization of the head to the opposite side of the catheter insertion and RIPS according to the patient's weight (1 mL per kilogram). |  |
|  | Initial location: contralateral subclavian vein.<br><br>Maneuver: Head elevation between 30° and 45° for 30 minutes and RIPS, according to the patient's weight (1 mL per kilogram). |  |

Source: The authors (2023).

## DISCUSSION

This study's results showed that the repositioning technique was effective in the majority of cases, with repositioning occurring on the first attempt. With regard to the sample studied, the findings converge with those found in the literature. In a study carried out in Belo Horizonte, Minas Gerais, the NBs who used the PICC were predominantly premature infants between 29 and 36 weeks of GA at the time of insertion, weighing between 1001 and 200 grams[2].

The identification of a majority of premature infants in samples using the PICC is common, given their need for infusion therapy to supply their organic and nutritional functions during their stay in the ICU until they are fully matured[9-11]. This infusion therapy is predominantly based on the use of antibiotics due to immune immaturity, invasive therapeutic procedures, and TPN used until the gastrointestinal tract matures[2].

In addition, invasive and noninvasive mechanical ventilation is frequently used in the treatment of prematurity due to pulmonary immaturity. This can cause increased intrathoracic pressure and influence catheter placement and repositioning. One study showed that the patient's greater clinical severity and the difference in venous flow caused by mechanical ventilation are factors that contribute to inadequate catheter tip placement.

After PICC insertion, assessment of catheter tip positioning is essential to maintain patient safety. The literature reports failure rates in the initial proper positioning of neonatal PICCs ranging from 25.7% to 39.4%[2-10]. If the catheter tip is poorly positioned, repositioning techniques are recommended[1]. A literature review that included studies evaluating catheter position and migration after insertion demonstrates techniques that can modify its positioning[4].

There was a higher incidence of malpositioning in the left basilic vein, which may be because it is a large vein and consequently one of the first chosen for catheter insertion. Similarly, because it is a longer route, this vein may be preferred by nurses, who adjust the catheter cut according to the route: first punctures are carried out in more distant locations, and then in locations with shorter routes, as seen in the service where the study was carried out. However, as it is located in the left limb, the route is longer, which increases the chances of adverse events[14]. In addition, there are recommendations for preferential insertion in the right upper limb, in the basilic vein, to reduce the chances of complications[15].

Combined PICC repositioning techniques were used in this study. The use of gravity by raising the head of the bed is a method that favors the migration of the catheter into the vessel with the blood flow. Natural changes in intrathoracic pressure allow the catheter to move within the vessel, due to the size and flow dynamics of the vessel[13]. Thus, as seen in this study, elevating the headboard, combined with other maneuvers, favored the migration of the PICC into the superior vena cava.

In a study carried out using upper limb movements, it was possible to identify body positions that direct the catheter towards the central position and others that move it away from this position, depending on the insertion vein. In this way, these positions contribute to the repositioning of the catheter tip[6].

Catheters inserted into the basilic vein: shoulder adduction and elbow flexion direct the catheter to the central position, while shoulder abduction and elbow extension move it to the peripheral position. In the context of the cephalic vein, shoulder abduction and

elbow flexion direct the catheter to the central region, while shoulder adduction and elbow extension move it to the periphery. In the case of catheters inserted into the axillary vein, shoulder adduction directs it to the central position, shoulder abduction to the periphery, and elbow movements have no effect[6].

In this study, when the catheters had their tips angled or rolled into the blood vessels, we opted for limb movement because this technique is capable of directing the catheter to the periphery6 and enabling alignment within the vessel. Associated with the infusion of saline solution, it facilitates migration to the central vessel when the patient is positioned.

Aspects that may favor the migration of the catheter tip from the jugular vein and contralateral subclavian vein to the central position include the fact that the jugular vein has no venous valves and the blood flow has vibrations that, when the limbs move, help to spontaneously reposition the catheter to the CAJ[16].

Another movement applied in the study was neck lateralization in two situations: when the catheter tip was lodged in the axillary vein and in the internal jugular vein ipsilateral to the PICC insertion. In the first case, the aim was to reduce the lumen of the jugular vein and limit the chances of the catheter migrating from the axillary vein to the jugular vein. This movement induces the catheter to migrate into the vena cava. In a study of PICCs inserted in the right upper limb, the researchers kept the arm abducted 90° from the patient's body and the head turned to the side ipsilateral to the insertion of the device to reduce the chances of the catheter migrating into the internal jugular vein[17].

In the second case, the neck movement used in this study was in situations where the PICC inserted in the upper limb was lodged in the jugular vein. In this context, the neck was rotated to the opposite side of the insertion vein, as the aim was to keep the jugular open and apply an adjuvant technique (infusion of saline solution) to make the catheter migrate into the vena cava. In both cases, it was found that the movement contributed to the purpose of the application.

The positioning of the intracardiac PICC was the most prevalent type of inappropriate PICC position. In this regard, one of the precautions prior to inserting the PICC is to measure the limb to be punctured. The data showed a variation of 1 to 5 excess centimeters (intracardiac), requiring traction and persisting from 1 to 2 cm in some cases. The average weight of 1,573 grams of the patients included in the sample is a predisposing factor to intracardiac catheter placement, due to the small size of the patient, in which small fractions of catheter length are able to make it long. This contributes to the high rate of intracardiac PICC placement.

In addition, a study was identified in the scientific literature that adapted the anatomical measurement technique for PICC insertion for premature NBs, taking into account the characteristics of this population[18]. Traditionally, anatomical landmarks are measured from the puncture point for catheter insertion to the right sternoclavicular space, up to the third right intercostal space, which measurement is used at the data collection site. The adapted proposal determines the measurement from the puncture site to the right sternoclavicular space, without advancing to the third intercostal space. The modified measurement technique for veins in the scalp and upper limbs proved to be more effective, minimizing the occurrence of intracardiac positioning[18].

Another technique used in this study was the rapid infusion of saline solution to direct the catheter tip to the central position. In line with this research, another study,

using a protocol based on scientific evidence for four months, infused a power flush (saline solution), which resulted in successful repositioning in most cases. The study demonstrated an alternative to previous practices, extending the time the catheter remained in place, reducing delays in treatment and unnecessary procedures, and showing significant savings for the institution[19].

We believe that further studies need to be carried out on this subject, and that information on catheter tip repositioning procedures needs to be systematized in order to encourage the use of care technologies that avoid new procedures. Despite the relevance of this study, the sample size does not allow the data to be generalized.

It is believed that the use of technologies with immediate images, such as bedside ultrasound or ultrasound-guided puncture, can help to reposition the catheter during insertion. However, despite the existing technologies, many hospitals rely exclusively on radiography as the method for locating PICCs, and this results in higher rates of post-insertion repositioning[4]. Therefore, repositioning techniques after insertion become relevant.

A limitation is the diversity of positions in which the tips could be found, limiting the sample to each bad position.

## FINAL CONSIDERATIONS

In this study, the techniques for repositioning the PICC catheter in neonates proved to be effective in cases of malpositioning in the contralateral subclavian vein, intracardiac vein, coiled in the jugular vein, coiled in the axillary vein, catheter coiled in the subclavian vein, and less effective in cases of nudging, regardless of the location.

Further studies on this subject are essential in order to increase the quality and safety of neonatal care, as well as rationalizing nursing work, with greater dedication to other activities aimed at the development of NBs, reducing the number of invasive procedures, and cutting hospital costs.

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Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work - **Pinto LVD, Kaufmann GW.** Drafting the work or revising it critically for important intellectual content - **Pinto LVD, Kaufmann GW, Giacomozzi CM, Sousa AC, Favero L.** Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved - **Pinto LVD, Kaufmann GW.** All authors approved the final version of the text.

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