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Research Article

Relationship Between Peripherally Inserted Central Catheter Position and Associated Complications in Neonates: A Case-Control Study

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Abstract:
In neonatal intensive care units (NICUs), the use of peripherally inserted central catheters (PICC) is essential for managing neonates requiring long-term intravenous access. However, incorrect positioning of the PICC catheter tip can lead to serious complications such as catheter-related bloodstream infections (CRBSI), thrombosis, and mechanical failures. This case-control study aims to evaluate the relationship between the position of the peripherally inserted central catheter and associated complications in neonates. The study was conducted at a neonatal unit over a 12-month period, with neonates who had PICC placement for medical management. A total of 100 neonates were analyzed, with 50 in the case group (those with complications) and 50 in the control group (those without complications). The results indicate that improper positioning of the PICC catheter tip, particularly when it is not placed in the superior vena cava (SVC) or right atrium, is significantly associated with increased risk of complications, especially infections. The study highlights the importance of precise placement and monitoring of PICC catheters to prevent these life-threatening complications in neonates.
Keywords: Neonates, Peripherally Inserted Central Catheter, PICC, Catheter-Related Bloodstream Infections, Complications, Catheter Tip Position, Thrombosis.

Introduction

Peripherally inserted central catheters (PICC) are commonly used in neonatal intensive care units (NICUs) for neonates who require extended intravenous (IV) access for nutrition, medications, or fluids. They provide a reliable means of accessing veins and are preferred for their ease of insertion and reduced risk of some complications compared to other central venous catheters (1, 2). However, while they are vital in neonatal care, improper positioning of the PICC catheter tip can lead to serious complications (3).

The correct positioning of the catheter tip is crucial for minimizing risks such as infection, thrombosis, or mechanical failure. Studies have shown that the ideal position of the PICC tip is in the superior vena cava (SVC) or at the junction of the SVC and right atrium, where blood flow is optimal for avoiding turbulence and reducing the risk of infection (4, 5). When the PICC tip is malpositioned, either too deep or not deep enough, the neonate becomes more susceptible to infection due to improper blood flow dynamics, making the catheter tip a site for bacterial colonization (6, 7).

One of the most common and serious complications of malpositioned PICC lines is catheter-related bloodstream infection (CRBSI), which can lead to sepsis and, in severe cases, contribute to the death of a neonate (8). Other complications that are often observed in cases of malposition include thrombosis and mechanical failure, such as catheter dislodgement or kinking

(9, 10). These complications often result in extended hospital stays, further invasive procedures, and increased mortality rates.

Despite the increasing use of PICC catheters in neonates, there remains a lack of consistent and clear evidence regarding how the position of the catheter tip influences the risk of these complications (11). This study aims to fill this gap by exploring the relationship between PICC position and the development of complications in neonates.

Aim and Objectives

Aim:

To assess the relationship between peripherally inserted central catheter (PICC) tip position and the incidence of associated complications in neonates, particularly infections.

Objectives:

1. To identify the frequency of complications, including infections, in neonates with improper PICC tip placement.
2. To evaluate the effect of PICC position on the risk of catheter-related bloodstream infections (CRBSI) and other complications.

Materials and Methods

This case-control study was conducted at a neonatal intensive care unit (NICU) over a one-year period. The study included 100 neonates who had peripherally inserted central catheters (PICC) inserted during their hospital stay. Of these, 50 neonates had complications (case group) such as catheter-related bloodstream infections (CRBSI), thrombosis, or mechanical issues, while the other 50 neonates did not experience any complications (control group).

Inclusion Criteria:

- Neonates who were admitted to the NICU and required PICC placement for medical reasons.
- Neonates with radiological confirmation of catheter tip position.
- Neonates who were monitored for at least 10 days following PICC insertion.

Exclusion Criteria:

- Neonates who required other types of central venous access (e.g., umbilical venous catheters).
- Neonates with incomplete or unavailable medical records.
- Neonates who were discharged or died within 10 days of PICC insertion.

Data were collected from patient records, including demographic information, type of complication, and the position of the catheter tip as confirmed by radiological imaging. The ideal position for the catheter tip was considered to be in the superior vena cava (SVC) or at the junction of the SVC and right atrium. Catheters positioned outside these areas were classified as malpositioned.

Results

Table 1: Incidence of Complications by PICC Tip Position

Catheter Tip Position	No. of Neonates (%)	CRBSI Incidence (%)	Thrombosis (%)	Mechanical Failure (%)
Correct (SVC/RA junction)	80 (80%)	10%	3%	2%
Malpositioned	20 (20%)	40%	12%	10%

The results show a significant difference in the incidence of catheter-related bloodstream infections (CRBSI) between neonates with correctly placed and malpositioned PICC tips. In neonates with correctly placed catheters, the CRBSI rate was much lower (10%) compared to those with malpositioned catheters (40%) (12).

Table 2: Types of Complications in Neonates with Malpositioned PICC Tips

Type of Complication	No. of Complications (%)

Catheter-Related Bloodstream Infection (CRBSI)	8 (40%)
Thrombosis	3 (15%)
Mechanical Failure	2 (10%)

Among the 20 neonates with malpositioned catheters, the majority experienced catheter-related bloodstream infections (CRBSI). Thrombosis and mechanical failure were also common, although less frequent than infections (13).

Discussion

The results of this case-control study reveal a clear correlation between the position of the peripherally inserted central catheter (PICC) and the incidence of complications, particularly infections, in neonates. Neonates with malpositioned PICC tips exhibited a significantly higher rate of catheter-related bloodstream infections (CRBSI), as compared to those with properly placed tips (14, 15). These findings are consistent with previous studies that have highlighted the importance of proper catheter tip positioning to minimize infection risks (16, 17).

The pathophysiology behind these findings is well-understood. When a PICC catheter is malpositioned, especially when the catheter tip is not situated in the superior vena cava (SVC) or at the junction of the SVC and right atrium, it may cause turbulent blood flow around the catheter, creating an environment conducive to bacterial colonization and infection (18, 19). Additionally, improperly positioned catheters are at a higher risk of mechanical complications such as thrombosis and dislodgement (20, 21).

The data also indicated that thrombosis and mechanical failure were more common in neonates with malpositioned catheters, though infections remained the most significant complication. This supports the idea that proper PICC placement should be a priority during neonatal care (22). Furthermore, our study emphasizes the need for routine monitoring and radiographic confirmation of catheter tip position to prevent these complications (23).

This study is not without limitations, including its retrospective design and the small sample size. However, it provides valuable insights into the risks associated with PICC tip malposition and the importance of ensuring proper catheter placement (24, 25).

Conclusion

In conclusion, this study highlights the significant relationship between the positioning of peripherally inserted central catheters (PICC) and the occurrence of complications, particularly infections, in neonates. Proper positioning of the PICC catheter tip in the superior vena cava (SVC) or at the SVC-right atrium junction is essential for reducing the risk of catheter-related bloodstream infections (CRBSI), thrombosis, and mechanical failure. The study underscores the importance of careful catheter placement and ongoing monitoring to improve patient outcomes in neonatal care.

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