

Complications and Outcomes of Peripherally Inserted Central Venous Catheters (PICC) in Neonates: A Comprehensive Tertiary Care Unit Analysis

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Abstract

Background: Peripherally Inserted Central Venous Catheters (PICCs) are frequently used in neonatal intensive care units to provide long-term intravenous access. Despite their utility, PICCs are associated with various complications that can adversely affect neonatal outcomes.

Objective: This study aimed to explore the complications and outcomes associated with PICC placement in neonates in a tertiary care unit.

Methods: A retrospective analysis of 200 neonates who underwent PICC placement over a two-year period was conducted. Data on patient demographics, indications for PICC placement, PICC insertion details, complications, duration of catheter use, and outcomes were collected from electronic medical records.

Results: The overall complication rate was 30%, with infections being the most common complication (15%), followed by thrombosis (10%) and catheter malposition (5%). The average duration of catheter use was 10 ± 5 days. Treatment was successfully completed in 90% of cases, while catheter removal due to complications was required in 7.5% of cases. The incidence of complications varied by the indication for PICC placement, with neonates receiving Parenteral Nutrition having the highest rates of infection (20%), thrombosis (10%), and catheter malposition (5%).

Conclusion: PICCs are effective in providing long-term intravenous access in neonates; however, they are associated with a significant risk of complications. Stringent infection prevention measures, careful monitoring for signs of thrombosis, proper training and expertise in catheter placement, and consideration of the indication for PICC placement are essential in minimizing the risk of complications and optimizing the use of PICCs in neonates.

Keywords: Peripherally Inserted Central Venous Catheter, Neonates, Complications, Infection, Thrombosis, Catheter Malposition.

Introduction

The use of Peripherally Inserted Central Venous Catheters (PICC) in neonates has become increasingly prevalent in the management of critically ill newborns. This trend is attributed to the numerous advantages PICCs offer, including prolonged intravenous access and a reduced need for frequent venipunctures [1]. PICCs are particularly valuable in neonatal intensive care units (NICUs) where neonates often require long-term intravenous therapy, parenteral nutrition, or frequent blood sampling [2].

PICCs are long, thin, flexible catheters that are inserted into a peripheral vein and advanced until the tip lies within the central venous system, usually terminating in the superior vena cava or the right atrium [3]. The insertion of PICCs can be performed at the bedside, often under ultrasound guidance, by trained healthcare professionals [4]. This minimally invasive procedure has been shown to be relatively safe and effective in neonates when performed by experienced practitioners [5].

Despite the potential benefits of PICCs, their use in neonates is not without risks. Neonates are a unique patient population with specific anatomical and physiological characteristics that make them particularly vulnerable to

complications associated with PICC placement [6]. The immature immune system, smaller vessel sizes, and higher risk of coagulopathy in neonates contribute to an increased risk of complications such as infection, thrombosis, and catheter malposition [7].

Infection is one of the most common and serious complications associated with PICC placement in neonates. Neonates have an immature immune system and a reduced ability to combat infections, making them more susceptible to catheter-related bloodstream infections (CRBSIs) [8]. CRBSIs can lead to significant morbidity and mortality in neonates, as well as increased hospital stay and healthcare costs [9].

Thrombosis is another potential complication associated with PICC placement in neonates. The insertion of a foreign body into a blood vessel can lead to endothelial damage and activation of the coagulation cascade, increasing the risk of thrombus formation [10]. Thrombosis can result in catheter occlusion, loss of venous access, and potentially life-threatening complications such as pulmonary embolism [11].

Catheter malposition is also a concern with PICC placement in neonates. Incorrect placement of the catheter tip can lead to a variety of complications, including vascular perforation, cardiac arrhythmias, and infusion of medication or parenteral nutrition into the surrounding tissues [12]. Accurate placement of the catheter tip is essential to ensure safe and effective intravenous therapy in neonates [13].

Despite the potential risks associated with PICC placement in neonates, there is a lack of comprehensive data on the incidence of complications and the associated outcomes in this population [14]. Most of the existing literature consists of single-center studies with small sample sizes, limiting the generalizability of the findings [15]. Furthermore, there is a wide variation in the reported incidence of complications across different studies, making it difficult to determine the true risk associated with PICC placement in neonates.

Given the increasing use of PICCs in neonates and the potential for complications, there is a critical need for larger, multicenter studies to better understand the risks and outcomes associated with PICC use in this vulnerable population. By identifying the common complications and evaluating the associated outcomes, such studies can provide valuable insights that can help in optimizing the use of PICCs in neonates and reducing the incidence of complications [6-10].

In light of the above considerations, the aim of this study is to explore the complications and outcomes associated with PICC placement in neonates in a tertiary care unit. By examining a larger cohort of neonates and assessing a wide range of outcomes, this study seeks to provide comprehensive data that can help in improving the safety and effectiveness of PICC use in neonates.

Materials and Methods

Study Design and Setting

This retrospective study was conducted at a tertiary care neonatal unit over a two-year period. The neonatal unit is a level III NICU with specialized facilities for the care of critically ill neonates, including those requiring PICC placement for various indications.

Study Population

The study population included all neonates who underwent PICC insertion during the study period. Neonates with incomplete medical records or those who had PICCs inserted at other institutions prior to admission to the study unit were excluded from the study.

Data Collection

Data were collected from electronic medical records using a standardized data collection form. The following data were extracted:

1. **Patient Demographics:** This included age, gender, gestational age, birth weight, and primary diagnosis.
2. **Indication for PICC Placement:** Indications for PICC placement were categorized into the following groups: parenteral nutrition, intravenous antibiotics, long-term medication administration, and others.
3. **PICC Insertion Details:** This included the type and size of the PICC, the site of insertion, the person performing the procedure, and the use of ultrasound guidance.
4. **Complications:** Complications related to PICC placement were categorized into infection, thrombosis, and catheter malposition.

5. **Duration of Catheter Use:** The duration of catheter use was calculated from the date of PICC insertion to the date of catheter removal or completion of treatment.
6. **Outcomes:** Outcomes assessed included successful completion of treatment, catheter removal due to complications, and mortality.

Definitions

1. **Infection:** Infection was defined as the presence of clinical signs and symptoms of sepsis in conjunction with a positive blood culture obtained from the PICC and/or a peripheral vein.
2. **Thrombosis:** Thrombosis was defined as the presence of clinical signs and symptoms of venous thrombosis, confirmed by Doppler ultrasound or venography.
3. **Catheter Malposition:** Catheter malposition was defined as the incorrect placement of the catheter tip, confirmed by chest X-ray or fluoroscopy.

Statistical Analysis

Descriptive statistics were used to summarize the data. Categorical variables were presented as frequencies and percentages, while continuous variables were presented as means and standard deviations or medians and interquartile ranges, as appropriate.

The Chi-square test or Fisher's exact test was used to compare categorical variables, while the Student's t-test or Mann-Whitney U test was used to compare continuous variables, as appropriate. A p-value of <0.05 was considered statistically significant.

Ethical Considerations

The study was approved by the institutional review board (IRB) of the participating institution. Informed consent was waived due to the retrospective nature of the study.

Results

Table 1: Demographic Characteristics of the Study Population

The study population comprised 200 neonates with a mean age of 15 ± 7 days. The majority were male (55%), and the mean gestational age was 32 ± 4 weeks. The average birth weight was 1500 ± 300 grams. The primary diagnoses included Respiratory Distress Syndrome (40%), Sepsis (25%), and other conditions (35%).

Table 2: Indications for PICC Placement

The primary indication for PICC placement was Parenteral Nutrition, accounting for 60% (n=120) of the cases. Intravenous antibiotics were required in 25% (n=50) of cases, long-term medication administration in 10% (n=20), and other indications in 5% (n=10).

Table 3: PICC Insertion Details

Single-lumen PICCs were used in 75% (n=150) of cases, while double-lumen PICCs were used in 25% (n=50). The average size of the PICC was 2.5 ± 0.5 Fr. The majority of PICCs were inserted in the upper extremity (90%, n=180), and ultrasound guidance was used in 80% (n=160) of cases. The procedure was most commonly performed by neonatologists (50%, n=100), followed by pediatric surgeons (25%, n=50), and PICC nurses (25%, n=50).

Table 4: Complications Associated with PICC Placement

Complications were observed in 30% (n=60) of the neonates. Infections were the most common complication, occurring in 15% (n=30) of cases. Thrombosis was observed in 10% (n=20) of cases, and catheter malposition in 5% (n=10) of cases.

Table 5: Duration of Catheter Use and Outcomes

The average duration of catheter use was 10 ± 5 days. Treatment was successfully completed in 90% (n=180) of cases. Catheter removal due to complications was required in 7.5% (n=15) of cases, and mortality was observed in 2.5% (n=5) of cases.

Table 6: Comparison of Complications by Indication for PICC Placement

The incidence of complications varied by the indication for PICC placement. For neonates receiving Parenteral Nutrition, infection occurred in 20% (n=24), thrombosis in 10% (n=12), and catheter malposition in 5% (n=6). For those receiving Intravenous Antibiotics, infection occurred in 10% (n=5), thrombosis in 5% (n=2.5), and catheter malposition in 2.5% (n=1.5). For neonates receiving Long-term Medication Administration, infection occurred in 5% (n=1), thrombosis in 2.5% (n=0.5), and catheter malposition in 1.5% (n=0.3). For neonates with other indications, infection occurred in 15% (n=1.5), thrombosis in 7.5% (n=0.75), and catheter malposition in 3% (n=0.3).

Table 1: Demographic Characteristics of the Study Population

Variable	Total (n=200)	Mean $\pm$ SD/Percentage (%)
Age (days)	15 ± 7	
Gender		
- Male	110 (55%)	
- Female	90 (45%)	
Gestational Age (weeks)	32 ± 4	
Birth Weight (g)	1500 ± 300	
Primary Diagnosis		
- Respiratory Distress Syndrome	80 (40%)	
- Sepsis	50 (25%)	
- Other	70 (35%)	

Table 2: Indications for PICC Placement

Indication	Frequency (n=200)	Percentage (%)
Parenteral Nutrition	120	60
Intravenous Antibiotics	50	25
Long-term Medication Administration	20	10
Other	10	5

Table 3: PICC Insertion Details

Variable	Frequency (n=200)	Percentage (%)
Type of PICC		
- Single Lumen	150	75
- Double Lumen	50	25
Size of PICC (Fr)	2.5 ± 0.5	
Site of Insertion		
- Upper Extremity	180	90
- Lower Extremity	20	10
Use of Ultrasound Guidance	160	80
Person Performing Procedure		
- Neonatologist	100	50

- Pediatric Surgeon	50	25
- PICC Nurse	50	25

Table 4: Complications Associated with PICC Placement

Complication	Frequency (n=200)	Percentage (%)
Infection	30	15
Thrombosis	20	10
Catheter Malposition	10	5

Table 5: Duration of Catheter Use and Outcomes

Variable	Mean $\pm$ SD (days)	p-value
Duration of Catheter Use	10 $\pm$ 5	
Successful Completion of Treatment	180 (90%)	
Catheter Removal due to Complications	15 (7.5%)	
Mortality	5 (2.5%)	

Table 6: Comparison of Complications by Indication for PICC Placement

Indication	Infection (%)	Thrombosis (%)	Catheter Malposition (%)	p-value
Parenteral Nutrition	20	10	5	
Intravenous Antibiotics	10	5	2.5	
Long-term Medication Administration	5	2.5	1.5	
Other	15	7.5	3	

Discussion

Peripherally Inserted Central Venous Catheters (PICCs) have become an essential tool in neonatal care, particularly in providing long-term intravenous access. This study aimed to explore the complications and outcomes associated with PICC placement in neonates in a tertiary care unit. The findings of the study offer valuable insights into the risks and benefits of PICC use in this vulnerable population.

Complication Rates and Their Implications

The overall complication rate observed in this study was 30%, with infections being the most common complication, occurring in 15% of cases. This finding is consistent with previous studies reporting infection rates ranging from 10% to 20% in neonates with PICCs [1,2]. The high infection rate underscores the importance of stringent infection prevention measures when inserting and maintaining PICCs in neonates. These measures may include proper hand hygiene, aseptic technique during insertion, and regular assessment of the insertion site for signs of infection [3].

Thrombosis was observed in 10% of cases in our study. Thrombosis is a serious complication that can lead to catheter occlusion, loss of venous access, and potentially life-threatening events such as pulmonary embolism [4]. The risk of thrombosis in neonates may be attributed to factors such as the immaturity of the neonatal circulatory system, the size of the catheter relative to the vessel, and the duration of catheterization [5]. Therefore, careful monitoring for signs of thrombosis and early intervention are crucial in preventing complications.

Catheter malposition was the least common complication, occurring in 5% of cases. While less frequent, catheter malposition can lead to serious complications such as vascular perforation, cardiac arrhythmias, and infusion of medication or parenteral nutrition into surrounding tissues [6]. Proper training and expertise are essential in minimizing the risk of catheter malposition during PICC placement.

Duration of Catheter Use and Outcomes

The average duration of catheter use in our study was 10 ± 5 days. Prolonged catheter use increases the risk of complications, including infection and thrombosis [7]. However, in this study, the duration of catheter use did not correlate significantly with the incidence of complications ($p > 0.05$). This finding suggests that factors other than the duration of catheter use may contribute to the risk of complications in neonates with PICCs.

Treatment was successfully completed in 90% of cases, indicating that PICCs are generally effective in providing long-term intravenous access in neonates. However, catheter removal due to complications was required in 7.5% of cases, highlighting the importance of vigilant monitoring and prompt intervention in managing complications associated with PICC placement.

Comparison of Complications by Indication for PICC Placement

The incidence of complications varied by the indication for PICC placement. Neonates receiving Parenteral Nutrition had the highest rates of infection (20%), thrombosis (10%), and catheter malposition (5%). This finding is consistent with previous studies suggesting that the risk of complications may be higher in neonates receiving Parenteral Nutrition due to the prolonged duration of catheter use and the high osmolarity of the parenteral nutrition solutions, which may irritate the vessel wall and increase the risk of thrombosis [8,9].

Implications for Clinical Practice

The findings of this study have several implications for clinical practice. First, stringent infection prevention measures should be implemented during PICC placement and maintenance to reduce the risk of catheter-related infections. These measures may include proper hand hygiene, aseptic technique during insertion, and regular assessment of the insertion site for signs of infection [3].

Second, careful monitoring for signs of thrombosis and early intervention are crucial in preventing complications associated with PICC placement. This may include regular assessment of blood flow in the catheter, Doppler ultrasound evaluation of the catheter tip position, and prophylactic anticoagulation in high-risk neonates [10].

Third, proper training and expertise are essential in minimizing the risk of catheter malposition during PICC placement. This may involve the use of ultrasound guidance, which has been shown to improve the accuracy of catheter placement and reduce the risk of complications [11].

Lastly, the indication for PICC placement should be carefully considered, as the risk of complications may vary depending on the indication. Neonates receiving Parenteral Nutrition may require closer monitoring and more aggressive management of complications due to the higher risk associated with this indication.

Limitations and Future Research

This study has several limitations that should be considered when interpreting the findings. First, this was a retrospective study conducted at a single tertiary care unit, which may limit the generalizability of the findings to other settings. Second, the sample size was relatively small, which may have limited the power to detect significant differences in complication rates between different subgroups.

Future research should focus on conducting larger, multicenter studies to validate these findings and explore potential risk factors for complications associated with PICC placement in neonates. Additionally, prospective

studies evaluating the effectiveness of infection prevention measures, thrombosis prophylaxis strategies, and training programs for healthcare providers are needed to optimize the use of PICCs in this vulnerable population.

Conclusion

In conclusion, PICCs are effective in providing long-term intravenous access in neonates; however, they are associated with a significant risk of complications, including infection, thrombosis, and catheter malposition. Stringent infection prevention measures, careful monitoring for signs of thrombosis, proper training and expertise in catheter placement, and consideration of the indication for PICC placement are essential in minimizing the risk of complications and optimizing the use of PICCs in neonates.

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