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Incidence of Nonelective Removal of Percutaneously Inserted Central Catheters According to Tip Position in Neonates

Priscila Costa, Mariana Bueno, Angelina Maria Aparecida Alves, and Amélia Fumiko Kimura

Correspondence
Priscila Costa, RN, Avenida Doutor Enéas de Carvalho Aguiar, 419, São Paulo, Brazil, 05403-000.
priscila2.costa@usp.br

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ABSTRACT

Objective: To compare the incidence and reasons for nonelective removal of percutaneously inserted central catheters (PICC lines) between centrally and noncentrally placed PICC lines in neonates.

Design: Prospective cohort study.

Setting: A 60-bed, tertiary-level neonatal intensive care unit in a private hospital in São Paulo, Brazil.

Participants: Neonates who were born at the hospital and underwent successful insertion of 237 PICC lines. They were divided into two groups, central and noncentral, according to tip position.

Methods: Neonates were monitored daily from insertion of the PICC until its removal. Data were collected from medical records.

Results: Of the 237 PICCs analyzed, 207 (87.4%) had their tip in a central position and 30 (12.6%) in a noncentral position. The incidence of nonelective PICC removal was similar between the central and noncentral groups ($p = .48$). The reasons for nonelective removal were significantly different between the groups ($p = .007$), with a higher incidence of extravasation in the noncentral group.

Conclusion: Noncentrally placed PICCs can provide vascular access in neonates requiring venous access for the administration of intravenous solutions. Many potential catheter-related complications can be prevented by careful bedside nursing. Frequent monitoring of noncentral PICCs is necessary to detect and prevent extravasation in neonates.

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Priscila Costa, RN, is a doctoral student in the Department of Maternal-Child and Psychiatric Nursing, School of Nursing, University of São Paulo, São Paulo, Brazil.

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Advances in neonatology and neonatal intensive care have improved the survival rates of very-low-birth-weight and ill preterm newborns. Consequently, an increasing number of newborns require safe vascular access. Because preterm newborns normally require parenteral nutrition, intravenous fluids, and medications such as antibiotics, caregivers are constantly challenged to improve methods of safe and consistent vascular access for this vulnerable population (Pettit & Wyckoff, 2007).

The insertion of percutaneously inserted central catheters (PICCs) for establishing vascular access carried out by registered nurses is increasing in frequency. It represents a cost-effective approach for providing vascular access. The PICC is a device inserted into a peripheral vein and threaded into the central venous circulation (Pettit & Wyckoff, 2007). To minimize the incidence of thrombotic complications, it is recommended that the tip of the catheter be placed in the central vasculature, for example in the superior vena cava (SVC) or inferior vena cava (IVC) (Infusion Nurses Society [INS], 2011).

In a clinical setting, the placement of the catheter tip in the recommended position is not always possible because of anatomical variations in the size of the vein or the confluence and obstruction of valves in the venous system. Therefore, the catheter's tip is occasionally placed in noncentral positions, such as the brachiocephalic, jugular, subclavian, axillary, iliac, or saphenous veins. Racadio, Doellman, Johnson, Bean, and Jacobs (2001) found a higher risk of complications and of

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nonelective removal associated with noncentrally placed PICCs in the pediatric population. The increasing complexity of neonatal care introduces new patient safety challenges. In neonatal nursing, the relationship between the catheter tip position and the incidence of nonelective removal of PICCs remains a complex issue that needs further evidence to inform nursing practice.

Background

Central vascular access devices are used for short- or long-term, continuous, or intermittent administration of infusions such as antineoplastic medications, vesicant or irritant fluids, parenteral nutrition, antibiotics, and any medication with a pH of <5 or >9 and osmolarity >600 mOsm/L (INS, 2011). PICCs offer a safe route for central venous access via cannulation of a peripheral vein for the delivery of hyperosmolar solutions and medications over prolonged periods of time (Hoang et al., 2008).

PICCs have gained widespread popularity because they are easily inserted. A high proportion of patients, approximately 8.3% to 33% in the neonatal intensive care unit (NICU), require PICC insertion (Hoang et al., 2008). The best location for the tip of a PICC is the lower third of the SVC, close to the SVC-RA junction (National Association of Vascular Access Networks [NAVAN], 1998). The tip of the catheter should not extend into the right atrium (RA) as this can cause cardiac complications. An ideal tip location allows the catheter to float freely within the lumen of the vein and lie parallel to the vessel wall, considerably reducing the risk of complications such as thrombosis and infection (NAVAN). Central location of the catheter tip could be crucial in providing venous access to a region of greater blood flow, thereby ensuring effective infusate hemodilution (Racadio et al., 2001). This allows the safe delivery of more concentrated parenteral nutrition and dextrose-containing solutions with higher caloric density, in addition to medications known to damage peripheral veins after repetitive administration (Pettit & Wyckoff, 2007). An increased incidence of catheter dysfunction and complications such as phlebitis, occlusion, and leaking were noted in children in whom the catheter tip was not positioned in the preferred sites such as the SVC or the SVC-RA junction (Racadio et al., 2001).

Racadio et al. (2001) analyzed data from 1,033 patients (mean age 6.49 years) who underwent 1,266 PICC insertions, of which 1,096 (87%) catheters were central and 170 (13%) were noncentral. The results indicated that central catheters were associated with fewer complications than noncentral catheters (3.8% vs. 28.8%). Central PICCs lasted significantly longer than noncentral catheters (16.4 vs. 9.3 days). However, the distribution of catheter sizes was different ($p < 0.01$) between central and noncentral groups. A higher proportion of smaller (2.0 Fr) catheters was found in the noncentral group compared to the central group (59% vs. 34%), in addition to a higher number of larger catheters (3.0, 4.0, and 5.0 Fr) in the central group.

Liu et al. (2009) investigated the risk factors associated with the nonelective removal of PICCs in 104 preterm infants (mean gestational age of 30.5 weeks). The authors reported that in the elective removal group 85 (93.5%) catheter tips were positioned at the junction of superior vena cava and right atrium, which was significantly higher than in the nonelective removal group ($p < 0.01$).

Conversely, in a prospective cohort study that included 587 PICCs inserted in children (mean age of 5.6 years.) Thiagarajan, Bratton, Gettmann, and Ramamoorthy (1998) noted that there were no significant differences in PICC losses caused by catheter-associated infection, exit-site infection, phlebitis, occlusion, or accidental dislodgement between catheters placed in central and noncentral locations. Central and noncentral PICCs had similar therapy completion rates (73% and 68%, respectively). Noncentral PICCs were shown to provide reliable and safe intravenous (IV) access for the administration of several medications and isotonic solutions for approximately 2 weeks. Therefore, the placement of PICCs in the central veins could be restricted to children in whom the type of therapy prescribed warrants central vascular access (Thiagarajan et al.).

Several authors have assessed the risks associated with noncentral placed PICCs in the pediatric population, however, the results remain controversial (Racadio et al., 2001; Thiagarajan et al., 1998). Further, the incidence of nonelective removal related to noncentral PICCs and complications associated with catheter tip location in the neonatal population remain unclear.

We hypothesized that noncentral PICCs may increase the incidence of nonelective removal compared to central PICCs in neonates. We compared the incidence of and reasons for nonelective

Mariana Bueno, RN, PhD, is a professor in the Department of Maternal-Child and Public Health, School of Nursing, Federal University of Minas Gerais, Minas Gerais, Brazil.

Angelina Maria Aparecida Alves, RN, PhD, is a professor in the Department of Maternal-Child Nursing, School of Nursing, Alfredo Pinto Federal University of Rio de Janeiro and Pedro Ernesto University Hospital, State University of Rio de Janeiro, Rio de Janeiro, Brazil.

Amélia Fumiko Kimura, RN, PhD, is a professor in the Department of Maternal-Child and Psychiatric Nursing, School of Nursing, University of São Paulo, São Paulo, Brazil.

The relationship between catheter tip position and the incidence of nonelective removal of PICC lines requires further investigation to inform neonatal nursing practice.

removal of PICCs between central and noncentral PICCs in neonates.

Methods

Study Design

This was a prospective cohort study. Enrolled neonates were divided into two groups according to the exposure variable: central and noncentral groups based on the catheter tip position. All neonates were monitored daily until the removal of the device, which was the main outcome variable.

Setting

This study was conducted in a 60-bed, tertiary-level NICU of a private hospital in the city of São Paulo, Brazil. The study protocol was approved by the Ethics Committee of the institution. At the institution, nurses are encouraged to participate in a training program that consists of didactic and practical development of clinical skills for PICC insertion, maintenance, and removal.

Procedures

In the NICU, the indications for PICC insertion were determined by an attending neonatologist and included the need for TPN with dextrose concentration >12.5%, continuous infusion of vesicant medications, therapies with variations in osmolarity or pH, and prolonged antibiotic therapy. A single lumen catheter was inserted for single-agent therapy, and a double lumen catheter was inserted for the delivery of multiple IV medications. No blood products were administered through the PICCs.

The PICC insertion procedure was performed by two nurses under sterile conditions. It was considered successful when the position of the catheter tip was confirmed and permitted for use after the assessment of a supine-position radiograph by the attending neonatologist and the nurses.

Maintenance care of each PICC was performed in accordance with the hospital protocol. It included a nursing and a medical prescription for each patient for the infusion therapy in use. All intravenous solutions were administered with infusion pumps. To maintain catheter patency, the device was flushed with saline solution, using a 10 ml syringe, before and after each drug infusion or every 6 hours. Saline solution was administered at a minimum rate of 0.5 ml/h when the catheter was being used for intermittent medication. The catheter hub was disinfected before access using an alcohol swab and wearing new clean gloves. Transparent semipermeable membrane dressings, sterile tapes, and surgical strips were changed every 7 days or earlier in case of loss of adhesion. All procedures related to the maintenance of the PICC were performed by the nursing staff and checked on the medical charts every work shift. The nurse supervisor at the NICU routinely instructed the nurse team about care of the catheter. Dwell time and PICC removal were determined by an attending neonatologist according to the patient's clinical condition, type of intravenous therapy, and functionality of the device.

Participants

The sample included neonates who were born at the hospital and underwent successful insertion of PICC lines (single lumen silicone 1.9 Fr or double lumen polyurethane 2.0 Fr PICC), had no other central venous catheter placed, and no congenital anomalies. The exclusion criteria were death of the infant, transfer to another hospital during follow-up, or no record of the tip position in the medical chart.

A statistical power analysis was used to calculate the required sample size. Based on the study by Racadio et al. (2001), assumptions were made as follows: $\alpha = .05$, power $= .80$, nonelective removal rate at centrally placed PICCs = 3.8%, allocation proportion = 6.5 (central catheter for each noncentral catheter) and relative risk = 5. The necessary sample size for a two-tailed test was estimated as 223 catheters, 193 in the central group and 30 in the noncentral group. Medical records of neonates were examined and data were collected between August 31, 2010 and July 01, 2011 until the number of noncentral catheters was reached, resulting in a sample of 237 catheters.

Study Variables

The following variables were collected: date of PICC insertion, main medical diagnosis, weight at the time of PICC insertion, postnatal and corrected gestational age at the time of PICC insertion, gender, catheter type (silicone or polyurethane), intravenous therapy indicating the need for PICC (total parenteral nutrition [TPN], antibiotic, general intravenous access), initial tip position, date of removal, reason for removal, and dwell time of the catheter. The catheter tip was considered central if

it was located at the superior or inferior vena cava, the junction of superior vena cava and right atrium, or at the right atrium. Catheter tips that were located at the axillary, subclavian, brachiocephalic, or iliac veins were considered noncentral.

A health care professional used the thoracic vertebral bodies (T) and the carina as anatomical landmarks to determine the location of the catheter tip on radiographs. Cases with unclear catheter tip location were discussed by the health care professional and the researcher. The catheter tip was considered to be located at the subclavian vein if it was located at the T1 level, brachiocephalic vein at the T2 level, SVC at the T3-T5 level, SVC-RA junction at the T6 level, or at two vertebral bodies under the carina and at the RA if it was located at the T7 to T8 level. It was considered to be at the IVC if it was located at the T9 to T10 level and at the iliac vein if it was below the T9 to T10 level (Mahlon & Yoon, 2007; Pettit & Wyckoff, 2007; Yoon et al., 2005).

Elective removal of the catheter occurred when it was no longer required (e.g., end of therapy). The following catheter-related complications resulted in nonelective catheter removal:

- Suspected catheter-related bloodstream infection: bacteremia or fungemia in a neonate who had an intravascular device with one or more positive blood culture results from samples drawn from the peripheral vein or central access or clinical manifestations of infection (fever or hypotension) with no other apparent sources of bloodstream infection (INS, 2011).
- Catheter occlusion: not possible to flush catheter with 1 ml of saline solution using a 10 ml syringe (Pettit & Wyckoff, 2007).
- Catheter fracture: rupture of an external segment of the device due to high pressure generated by using a small-volume syringe for infusion or flushing against resistance (Pettit & Wyckoff, 2007).
- Accidental dislodgement: inadvertent partial or complete removal of the catheter from the infant's body (Pettit & Wyckoff, 2007).
- Tip migration: spontaneous movement of the tip of the catheter at any time while in situ, leading to a peripheral location identified on the radiograph.
- Extremity edema: mild to severe edema in the area surrounding the catheter insertion site or in the extremity associated with the catheter (Pettit & Wyckoff, 2007).
- Extravasation: escape of potentially injurious solutions from the walls of the vein causing skin redness, edema and discoloration (Beauman & Swanson, 2006).
- Phlebitis: inflammatory reaction in the vein associated with the placement and dwelling of a catheter. Identified by erythema or palpable venous cord at the vein (INS, 2011; Pettit & Wyckoff, 2007).

Analysis

The demographic characteristics of the patients were compared using the chi-squared test for categorical data and Student's *t* test for continuous variables. The chi-squared test was used to compare the incidence of nonelective catheter removal between the groups. The relative risk for nonelective removal of the catheter, according to the exposure variable, was also estimated with a 95% confidence interval (CI). The reasons for nonelective removal of catheters were compared using the Monte Carlo chi-squared test. Monte Carlo tests may be valid when the number of observed counts in a cell is zero as long as the expected number is less than five in 80% of the cells and greater than one in all cells. The Monte Carlo *p* value is based on a random sample of a probability distribution rather than a chi-squared distribution which is an approximation. When the Monte-Carlo option is used, the *p* value will vary each time the test is run on the same data set because it is based on a random sample of probabilities (Peat & Barton, 2005). If a statistical difference was observed, a chi-squared test with residual analysis was conducted. The incidence density for the different reasons for nonelective removal of the catheter was measured as catheter-related complications per 1,000 catheter days. For all statistical analyses, $p < 0.05$ with a 95% CI was considered statistically significant.

Results

Of the 263 PICCs recorded in this study, data collection was completed for 237 catheters (Figure 1) and for 200 neonates. The distal tips of 207 (87.4%) catheters were placed in central veins (central group), and those of 30 (12.6%) catheters were placed in the noncentral veins (noncentral group). The distal tip location was the superior vena cava in 155 (65.4%), inferior vena cava in 26 (11%), subclavian vein in 24 (10.1%), junction of superior vena cava and right atrium in 14 (5.9%), the right atrium in 12 (5.0%), iliac vein in 4 (1.7%), and the axillary vein in two (0.9%) PICCs.

There were no significant differences in the completion of therapy between centrally and noncentrally placed PICCs.

No significant differences were observed between the groups with regard to demographic variables (Table 1). The main indication for catheter placement was antibiotic infusion in 198 (83%) patients, and there were no significant differences between the groups ($p = .97$). The indication for administration of TPN was similar in both groups ($p = .85$) and was also similar in the groups ($p = .87$) for other intravenous fluids (e.g., dopamine, dobutamine, furosemide, aminophylline). The 1.9 Fr single lumen silicone PICC was used on 132 (63.8%) occasions in the central group and on 23 (73.7%) occasions in the noncentral group, with no statistically significant differences between the two groups ($p = .2$).

There were no significant differences regarding completion of therapy between central and noncentral PICCs. One hundred and forty-nine (62.3%) catheters were removed because they were no longer required. The incidence of nonelective removal of the devices was similar between the groups ($p = .48$) and was not associated with tip location (relative risk [RR] = 1.18, 95% CI [0.76, 1.84]) (Table 2). The incidence density of nonelective removal was 44.2 per 1,000 catheter-days in the noncentral group and 31.34 per 1,000 catheter-days in the central group. The most frequent catheter-related complications were suspected catheter-related bloodstream infection, catheter occlusion, and catheter fracture.

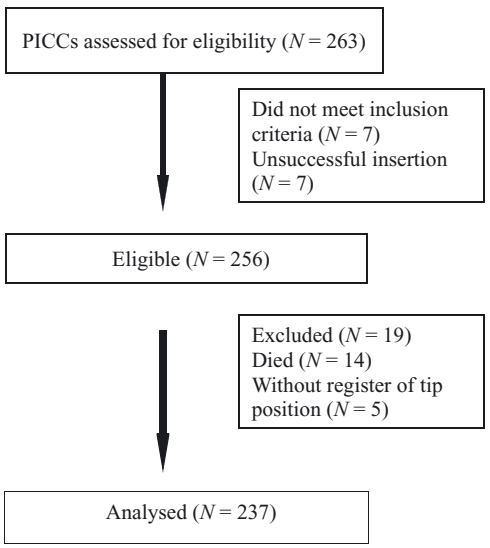

Figure 1. Flow of participants. PICC = percutaneously inserted central catheters.

There were significant differences in the reasons for nonelective removal between the central and noncentral groups (Table 3). The chi-squared residual analysis test showed a significant difference between the observed and expected incidence of extravasation in the noncentral group. The incidence of extravasation was higher in the noncentral group than in the central group.

The average indwelling duration of PICCs was 11.4 days (range: 1–70 days). The mean indwelling duration was 11.7 days (±9.9 days) in the central group and 9.8 days (±9.03 days) in the noncentral group, but the difference was not statistically significant ($p = .16$).

Table 1: Demographics and clinical characteristics of the neonates

	Central Group	Noncentral Group	*p* Value
Diagnose of prematurity[a]			
Yes	170 (82.1)	23 (76.7)	0.47
No	37 (17.9)	07 (23.3)	
Gender[a]			
Male	123 (59.4)	18 (60)	0.95
Female	84 (40.6)	12 (40)	
Corrected gestational age (wk)[b]	37.1 (4.15)	33.8 (3.79)	0.33
Postnatal age (days)[b]	9.9 (17.6)	10.4 (16.5)	0.44
Weight (g)[b]	1936.8 (846)	1867 (858.7)	0.33

Note.[a] Values given as *n* (%).
[b]Values given as mean (*SD*).

Table 2: Nonelective removal incidence and relative risk according to catheter tip position of PICC

Tip position	Nonelective removal *n* (%) Yes	No	*p* Value	Relative Risk
Noncentral	13 (43.3)	17 (56.7)	0.48	1.18 [CI: 0.76, 1.84]
Central	76 (36.7)	131 (63.3)		

Table 3: Reasons for nonelective removal according to catheter tip position of percutaneously inserted central catheters (PICCs)

Reasons for nonelective removal	Central Group ($n = 76$)		Noncentral Group ($n = 13$)		
	n (%)[a]	Incidence Density[a]	*N* (%)	Incidence density	*p* Value
Suspected catheter-related bloodstream infection	23 (30.3)	9.5	3 (23.1)	10.2	0.007
Catheter occlusion	19 (25)	7.8	–	–	
Catheter fracture	15 (19.7)	6.2	1 (7.7)	3.4	
Catheter dislodgement	10 (13.2)	4.1	4 (30.8)	13.6	
Tip migration	4 (5.3)	1.6	–	–	
Extremity edema	3 (3.9)	1.2	2 (15.4)	6.8	
Extravasation	2 (2.6)	0.8	3 (23.1)	10.2	

Note. [a]Values given per 1,000 catheter-day.

Discussion

In a neonatal clinical setting, PICCs are occasionally placed in a noncentral vein because of the anatomy of the venous system or insertion techniques. The rates of noncentral PICCs found in this study are similar to those found in previous studies on neonates. In a prospective study that included 47 PICCs inserted in 41 preterm infants over a 1-year period in an NICU in Saudi Arabia, Tawil, Eldemerdash, Hathlol, and Laimoun (2006) noted that 87.2% of the devices were central whereas 12.8% were noncentral. Comparable results were found in a retrospective study with medical charts of 61 newborns that had double lumen 3.0 Fr polyurethane PICCs inserted. The authors showed that the catheter tip was in the superior vena cava in 65.5% cases and in the subclavian vein in the remaining 34.5% (Bueno, Cervera, Rodriguez, & Quero, 2008).

The placement of the tip of the PICC in the superior or inferior vena cava allows the safe administration of concentrated parenteral nutrition and medications such as vancomycin and phenobarbital that are known to cause damage to peripheral veins after prolonged use. In this cohort study, we compared the incidence of nonelective removal of PICCs between central and noncentral PICCs in neonates and investigated the possibility of using noncentral devices for safe vascular access. The nonelective removal rate of 43.3% in the noncentral group in this study was similar to those of prior reports that included central and noncentral PICC lines. In a retrospective study that included 167 infants who underwent 241 PICC placements in a Brazilian NICU, Franceschi and Cunha (2010) reported a nonelective removal rate of 47.7%. Njere, Islam, Parish, Kuna, and Keshtgar (2011) studied 226 neonates requiring surgical treatment who underwent 302 PICCs insertions at a prospective study in a tertiary level NICU in London, UK, and reported a nonelective removal rate of 46.3%.

The efficacy and safety of central versus noncentral PICCs is the subject of controversy. Like the study conducted by Thiagarajan et al. (1998), our findings suggested that noncentral placement of the catheter tip was not associated with a risk of nonelective removal. Moreover, the noncentral catheter tip position was not related to a shorter indwelling time of the device.

Despite the reported benefits of PICCs in neonatal care, they are commonly associated with mechanical and infectious complications. Mechanical complications, including occlusion, extravasation, dislodgement, and thrombosis, occur in 15% to 48% of inserted catheters (Shah & Shah, 2009). In this study, suspicion of catheter-related bloodstream infection was the most common reason for nonelective removal of the catheters. The incidence of this complication in PICC lines ranges from 0% to 11.8% or 0 to 15.8 episodes per 1,000 catheter-days, with higher rates occurring in neonates weighing less

The incidence of nonelective removal was similar between central and noncentral PICC lines in the neonates.

than 1500 g (Golombek, Rohan, Parvez, Salice, & LaGamma, 2002). In the noncentral group the most common complication leading to nonelective removal was catheter dislodgement. At a prospective study conducted in New York, New York, involving 47 neonates and 57 PICCs inserted, Golombek et al. reported a catheter dislodgement incidence of 8%.

A noncentrally placed PICC can be a suitable intravascular device for neonates with difficult venous access or for those highly sensitized to multiple needle punctures even if they require TPN or antibiotic therapy. However, in this study, the incidence of extravasation was higher in the noncentral group than in the central group. Although significance was found, the number of catheters in the noncentral group was much smaller than in the central group. The difference in absolute number of extravasation was only one catheter between the groups. The rate of this complication in this study was only 2.1% including all PICC lines inserted.

We showed that extravasation is a complication with a low incidence in newborns with PICC lines. This catheter-related complication occurs when fluid comes out of the vessel, either due to catheter dislodgement or erosion through the vessel. This is more common in peripheral IV therapy with an incidence rate ranging from 0% to 78%. As intravenous extravasations are estimated to occur in 11% of NICU patients, it seems that adopting PICC lines as vascular access in clinical practice reduces this complication, although these catheters have their own risk of venous erosion (Thigpen, 2007). In a prospective study to assess the quality assurance of 185 single lumen polyurethane, Paulson and Miller (2008) reported that 1.9 Fr PICCs inserted between 1998 and 2005 showed an infiltration or leakage rate of 15.4% for midline catheters and 0% for centrally placed PICCs (Paulson & Miller). Midline catheters are peripheral infusion devices with the tips terminating in either the basilic, cephalic, or brachial veins, distal to the shoulder (INS, 2011).

Nurses should frequently monitor the catheter site to detect any signs of extravasation. Signs and symptoms of this complication include swelling, pain at the site, coolness of the skin, leakage at the site, erythema, blistering, and in some cases lack of blood return. This complication results in varying degrees of morbidity. The severity of damage depends on the volume and type of fluid or medication infiltrated. Serious extravasation can result in pain, infection, disfigurement, prolonged hospitalization, increased hospital costs, and possible litigation (Thigpen, 2007).

Study Limitation

Although we analyzed a cohort of 237 PICCs, some limitations should be considered. The nonelective removal rate was much higher than in the study used to estimate the sample size. Future other studies should be conducted with a larger sample size from the neonatal population. Likewise the comparison between central and noncentral groups may be affected by the small number of noncentral PICCs included in the analysis, which does not generate definitive conclusions regarding the safety of noncentral PICCs in neonates. Moreover, the results represent the use of PICC lines in a single private hospital with a specific nursing team.

Implications for Clinical Practice

Noncentral PICCs can be considered as an option to provide vascular access in neonates requiring venous access for the administration of different medications and general intravenous solutions for almost two weeks.

Careful bedside nursing care can prevent many of the potential complications that lead to nonelective removal of PICCs. Neonatal intensive care nurses should frequently monitor neonates with noncentral PICCs for the initial signs of extravasation. Preventing this complication is the first step in avoiding tissue injury. Some strategies include, whenever possible, avoiding placement of the device in areas that are difficult to immobilize, especially near areas of flexion or surrounding tendons, nerves, or arteries. In addition, securing the device with transparent adhesive dressing or clear tape so the insertion site is clearly visible is recommended. Tape should also be placed loosely over bony prominences to prevent obstruction of venous return. Appropriate documentation should be updated, at least hourly. If signs of extravasation are noted, the nurse should stop the infusion immediately (Thigpen, 2007). Treatment of infiltration and extravasation depends on the severity of the injury when it is detected and may include extremity elevation, thermal

manipulation, use of antidotes, and surgical intervention (INS, 2011).

Some other recommendations for clinical practice are related to prevention of catheter-related bloodstream infection, since this is the primary reason for nonelective removal. Consistent, meticulous sterile techniques during insertion of PICCs can reduce the risk of this complication. Decreasing catheter manipulation is also a key to prevention. Every time the device is manipulated, the risk of infection increases. Hands should be washed before every line entry, and hubs or IV injection sites should be cleaned with antiseptic and allowed to air dry before the line is entered (Paulson & Miller, 2008). The adoption of a PICC team including members of the nursing staff who are considered to be experts is also a helpful strategy. The team's role could be inserting and removing PICC lines, changing dressings, maintaining skills competency, and familiarity with standards of practice and developing educational activities for nursing staff (Sharpe, 2006).

Further evidence-based studies are necessary to support clinical nursing practice. Certainly replication of this study with a larger number of catheters might move knowledge ahead in this area. Similarly, other studies need to be conducted considering topics such as the effectiveness of flushing with saline solution and heparin, establishing volumes, concentration and periodicity of flushing, as well as frequency of changing PICC dressing in the neonatal population. All these activities may be related to complications, for example, catheter occlusion, fracture, catheter-related bloodstream infection, and accidental dislodgement.

Conclusion

Our results suggested that the position of the catheter tip is not significantly associated with the incidence of nonelective removal of PICCs in neonates. There were no significant differences in the completion of therapy between centrally and noncentrally placed PICCs. Noncentrally placed PICCs can be considered as an option to provide vascular access, however there is a higher incidence of nonelective removal because of extravasation.

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