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Research Article

Management of Malpositioned Peripherally Inserted Central Venous Catheter in the Upper Extremity of Neonates

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Abstract

Background: Peripherally inserted central catheters (PICCs) are extensively used in neonatal intensive care.

Aim: We report 12 cases of neonates with catheter management of malposition on initial peripherally inserted central venous catheter (PICC) placement.

Materials and Methods: Between July 2018 and July 2020, a cross-sectional retrospective study was conducted on neonates hospitalized in the newborn intensive care unit. Patients with PICC were obtained from file records and automation system. In patients with catheter malposition, the radiological images of the catheter before and after repositioning, gender sex, gestational week, delivery type, birth weight, aim of insertion, and insertion time of postnatal day were evaluated. The usability of the catheter and complications after repositioning in patients with catheter malposition were determined.

Results: The procedure was successful in 233 (91.7%) of 254 patients whose catheters were inserted in the upper extremity. The mean gestation week, body mass index, birth weight, and birth height were 33.92 ± 4.03 ((27-38) weeks, 1.11 ± 0.26 (0.86 - 1.66) kg/m^2, 2195 (1050 - 3800)g and 42.83 ± 7.31 (35 - 54) cm, respectively. In the catheter position control radiographies, 12 (5.2%) patients with inappropriate catheter tip localization were evaluated as catheter malposition and repositioning was performed. The most common localization of catheter malposition was most commonly found in the axillary (50%), internal jugular (33.3%), and thoracodorsal veins (16.7%), respectively.

Conclusion: Appropriate position of the catheter can reduce complications in patients with PICC malposition and allow long-term vascular usage.

Keywords: Neonate; Peripherally Inserted Central Catheter; Radiography; Reposition; Tip Position

Introduction

Peripherally inserted catheter (PICC) is known as the ''lifeline'' of critical neonates because of its irreplaceable role in rescuing neonates. PICC is routinely used in preterm and term neonates to provide intravenous access for prolonged therapy, total parenteral nutrition (TPN) and poor peripheral venous access [1,2]. They are

known to reduce the complications associated with conventionally used central catheters. Advantages of PICC over centrally inserted venous catheters include the markedly reduced risk of procedure-related trauma, such as hemothorax, pneumothorax, and accidental arterial puncture.

PICC can be conveniently inserted at bedside without need for surgical intervention. PICC has been widely used in the neonatal intensive care unit (NICU) for 20 years. The optimal position of the PICC tip remains controversial. Upper extremity PICC lines were considered to be in a central position if the catheter tip was in or proximal to the brachiocephalic vein (distal subclavian vein was sometimes considered central). Another recommendation for upper extremity or scalp insertion is placement of the catheter tip in the lower half to one-third of the superior vena cava, sometimes delineated as T3-T5. PICC malposition was defined as a line placed in an artery or a line tip not in a central venous location. Identifying the PICC tip position is essential to assess the suitability of PICC placement and application. Chest radiography is the most frequently used method to define the suitable position of the PICC tip and regarded as the gold standard [3-5].

PICC is made of polyurethane or silicone, both of which are biocompatible. The tip of these longlines is ideally positioned in administration of solution of high osmolarity (≥ 900 mOsm/L) without causing major venous injury.

In neonates, the main complications related to the use of PICC are catheter-related bloodstream infections, catheter occlusion/malfunction, bleeding, pain, clot, thrombosis, line fracture, arrhythmia, phlebitis, breakage, migration, and displacement, which lead to nonselective catheter [6,7]. Particularly, occlusion and bloodstream infection are the two most commonly reported long-term problems. The incidence of complications in neonates varies markedly among studies, from 0% to 34%, with obstruction highlighted as one of the major mechanical complications [8-11]. Studies have shown that limb movement, neck position, and forceful flushing during insertion may change the tip position of the PICC line. Catheters in situ can be displaced because of hemodynamics, especially external physical forces [9,12]. PICC should be well fixed to avoid misplacement,

Aim of the Study

This study aimed to determine the incidence of PICC displacement complication in a neonatal population. We hypothesized that upper extremity PICC would be used after our reposition procedure.

Materials and Methods

Ethical approval: This study was approved by the university/local human research ethics committee, and all procedures involving human participants were in accordance with the ethical standards of the institutional and/or national research committee e and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards (protocol number: 2020.185.07.18).

PICC placement: PICCs were placed by nurses who were members of the neonatal PICC team and neonatologists. In most cases, the upper limb approach was preferred because more veins are available, and the distance from the vena cava is shorter. Line size was based both on preference of the medical team and size of the neonate (particularly 1or 2 Fr**, polyurethane, nutriline/vygon**^{R}). The catheter was inserted under sterile conditions at bedside. Heparin was added to TPN at a dose of 0.5 IU/ml under sterile conditions. In our NICU, the upper half region of the superior vena cava and brachiocephalic vein are considered reliable locations for catheter.

Study design: The electronic NICU medical records from July 2018 to July 2020 of all infants with PICC placed during the neonatal period at our institution were retrospectively reviewed. As a standard procedure, images were obtained at bedside after catheter insertion by using a mobile digital X-ray device (Ekol ltd, drgem topaz^{R}), which enables instant imaging, wireless image transfer, and measurements. Antero-posterior or lateral X-ray of neonates with PICC between 24 and 46 gestational weeks were investigated from the electronic recording system. Same neonatologist and same radiologist examined the images after catheter repositioning procedure in patients with malpositioning after catheter insertion.

Gestational week, gender, delivery type, birth weight, birth height, body mass index (weight/height x height; gram/cm), postnatal day (catheters placed time), placement indication, repositioning application, catheter dwell time and possible complications after the procedure were evaluated.

Statistical analysis: SPSS v17 statistics package program was used to assess data. One-sample Kolmogorov-Smirnov test was used to evaluate data in terms of normal distribution. Data suitable and not suitable for normal distribution were presented as arithmetic mean and standard deviation, and median (minimum -maximum)

values, respectively, and descriptive analysis was performed. Chi-squared test was used for sex, delivery mode, catheterization, and corrected catheter localization. The non-parametric Mann-Whitney U test was used to evaluate the relationship between the defined parameters and gender. In this study, statistical significance was accepted at $p < 0.05$.

Results

Patient population

Case 1: A female neonate delivered at 34th gestational week was implanted with PICC on the 3rd postnatal day. However, the PICC progressed in the trace of basilic vein of the right upper extremity, curled after passing the axillary level, and ended at the thoracodorsal vein. After retracting 3 cm, the PICC ended at the axillary vein (Figure 1). The catheter was used longline for 8 days without complications.

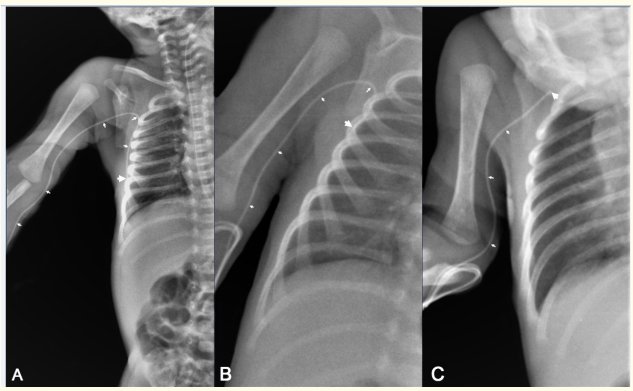

Figure 1: A PICC progressed in the trace of the right basilic vein, curled after passing the axillary level, ending the thoracodorsal vein. After withdrawal of the PICC, it ended at the axillary vein.

Case 2: A female neonate delivered at 36th gestational week was implanted with PICC on the 6th postnatal day. After passing the axillary level in the right upper extremity, the bent catheter was brought to the appropriate position after retracting 1.5 cm. The catheter was used longline for 7 days without complications.

Case 3: A male neonate delivered at 38th gestation week was inserted with PICC on the 12th postnatal day. The PICC line progressed to the cephalic vein of the right upper extremity and looped at the level of the axillary vein. After retracting 3.8 cm, the catheter was brought to the appropriate position in the axillary vein. The catheter was used as longline for 10 days without complications.

Case 4: A male neonate delivered at the 29th gestational week was implanted with PICC on the 21st postnatal day. PICC was seen to curl in the right upper extremity basilic vein. The catheter was observed in the subclavian vein after abducting the arm and withdrawing 1 cm. The catheter was used as longline for 10 days without complications.

Case 5: A female neonate delivered at 37th gestation week was implanted with PICC on the 21st postnatal day. The catheter progressing in the cephalic vein of the right upper extremity was seen in the right internal jugular vein. By abducting the right arm at 30° degrees after lifting the head and neck 45° to the midline, the catheter ended at the proximal superior vena cava. The catheter was used as a central catheter for 14 days without complications (Figure 2).

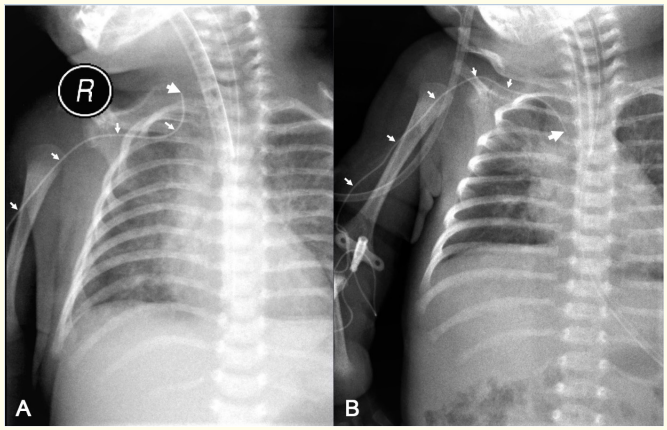

Figure 2: Shows a catheter progressing in the cephalic vein of the right upper extremity which tip was located in the right internal jugular vein. By manipulating the catheter, it ended at the proximal superior vena cava.

Case 6: PICC was inserted on the 3rd postnatal day of a female neonate at 31st gestation week. The image showed the PICC line in the left upper extremity, forming a loop by bending after crossing the axillary vein and ending at the axillary vein level. PICC was retracted 3.5 cm and used longline for 10 days without complications.

Case 7: A female neonate delivered at 38th gestational week was implanted with PICC on the 10th postnatal day. The PICC curled at the basilic vein after passing the axillary vein along with the cephalic vein in the left upper extremity. After retraction by 3.6 cm, it ended at the axillary vein. The catheter was used longline for 7 days without complications.

Case 8: A female neonate delivered at 38th gestational week was implanted with PICC on the 15th postnatal day. The PICC progressed in the trace of the cephalic vein in the right upper extremity and looped through the axillary vein toward the basilic vein. After retraction by 4 cm, the PICC ended in the right axillary vein. The catheter was used longline for 10 days without complications.

Case 9: A female neonate delivered at 37th gestational week implanted with PICC on the 18th postnatal day. After progressing to the level of the axillary vein in the cephalic vein of the right upper extremity, then curled and terminated at the thoracodorsal vein trace. The catheter was retracted 2.4 cm and used longline for 10 days without complications.

Case 10: A female neonate delivered at 33rd gestational week was inserted with PICC on the 5th postnatal day. The PICC progressed in the cephalic vein trace in the right upper extremity and ended in the right internal jugular vein. By abducting the arm at 30° and lifting the head and neck at 45° to the midline, the catheter was observed in the subclavian vein. It was used as a central catheter for 14 days without complications.

Case 11: A male neonate delivered at 27th gestational week was implanted with PICC on the 12th postnatal day. The catheter was progressing through the cephalic vein trace of the right upper extremity and terminated in the right internal jugular vein. After withdrawing 3 cm, the PICC was observed at the subclavian vein (Figure 3). It was used as a central catheter for 14 days without any complications.

Patient 12: A male neonate delivered at 29th gestational week was implanted with PICC on the 21stpostnatal day. The catheter was progressing through the basilic vein trace in the left upper extremity and ended in the right internal jugular vein. After withdrawing 1.9 cm, its tip was observed at the subclavian vein. It was used as a central catheter for 14 days without complications.

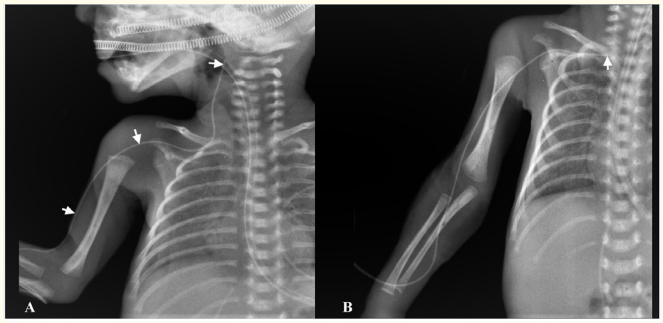

Figure 3: Shows the catheter progressing through the cephalic vein trace of the right upper extremity, terminating in the right internal jugular vein. After retraction, the PICC was observed at the subclavian vein.

Between July 2018 and July 30, 2020, PICC was implanted in 254 patients in the NICU. Malposition was detected in 12 (5.15%) of 233 (91.73%) patients whose PICC procedure was successful. The major indication for catheter placement in patients (100%, n = 12) was peripheral vascular access problem and TPN requirement.

In the study population, 4 (33.3%) and 8 (66.7%) of the patients were boys and girls, respectively. The mean postnatal day at catheter insertion was 11.83 ± 7.22 (3-26) days (Table 1).

Six (50%) of the patients were delivered via normal spontaneous delivery. Of the neonates delivered normally, 1 (16.7%) was a boy, and 5 (83.3%) were girls. Of those delivered via cesarean section, 3 (50%) were boys, and 3 (50%) were girls.

Seven of the patients with PICC malposition were delivered preterm (58.3%). The mean gestation week, body mass index, birth weight, and birth length were 33.92 ± 4.03 (range: 27 - 38) weeks, 1.11 ± 0.26 (range: 0.86 - 1.66) kg/m^2, 2195 ± 1091.28 (range: 1050 - 3800)g, and 42.83 ± 7.31 (range: 35 - 54) cm, respectively. The most common localization of catheter malposition was the axillary (50%, n = 6), internal jugular (33.3%, n = 4) and thoracodorsal veins (16.7%, n = 2). In terms of side localization, it was observed at the right axillary vein in four patients (left, n = 2), right internal jugular vein in three patients (left, n = 1), and right thoracodorsal vein in two patients. Of the patients with catheters in the

Patients	Gestational week (gw)	Birth weight (gram)	Birth height (cm)	Gender	Delivery type Cesarean = CS Normal = N	BMI (weight/height^2)	Postnatal day
1	34	1330	39	Female	CS	0.87	3
2	36	1980	41	Female	CS	1.18	6
3	38	3370	45	Male	CS	1.66	12
4	29	1050	35	Male	CS	0.86	10
5	37	2390	51	Female	N	0.92	26
6	31	1280	31	Female	N	0.99	3
7	38	3800	54	Female	N	1.3	11
8	38	3800	54	Female	N	1.3	15
9	37	3210	47	Female	CS	1.45	18
10	33	1980	42	Female	N	1.12	5
11	27	1100	35	Male	N	0.9	12
12	29	1050	35	Male	CS	0.86	21

Table 1: Demographic characteristics of patients with peripheral central venous catheter.

axillary vein, 33.3% (n = 2) and 66.7% (n = 4) were boys and girls, respectively. All of those with catheters in thoracodorsal vein were girls (n = 2), and half of those with catheters in the internal jugular vein (n = 4) were also girls. Right-sided catheter malposition was present in 75% (n = 3/4) and 75% (n = 6/8) of male and female neonates, respectively. After correcting the catheter malposition, its localization was determined as axillary vein (66.7%, n = 8), superior vena cava (8.3%, n = 1), and subclavian vein (25%, n = 3). In terms of side localization, it was observed at the right axillary vein (left n = 2) in six patients, superior vena cava in one patient, and right subclavian vein in two patients (left n = 1) (Table 2).

	Malposition of the catheter			Corrected catheter position		
Catheter Tip	AV (50%, n = 6)	IJV (33.3%, n = 4)	TDV (16.7%, n = 2)	AV (75%, n = 8)	VCS (16.7%, n = 1)	SCV (25%, n = 3)
Side	Right (66.7%, n = 4/6)	Right (75%, n = 3/4)	Right (100%, n = 2/2)	Right (75%, n = 6/8)	Right (100%, n = 1)	Right (66.7%, n = 2/3)
	Left (33.3%, n = 2/6)	Left (25%, n = 1/4)	0	Left (25%, n = 2/8)	0	Left (33.3%, n = 1/3)
Gender	Male (n = 2/6, 33.3%)	Male (n = 2/4, 50%)	0	Male (n = 2/8, 25%)	0	Male (n = 2/3, 66.7%)
	Female (n = 4/6, 66.7%)	Female (n = 2/4, 50%)	Female (n = 2/2, 100%)	Female (n = 6/8, 75%)	Female (n = 1/1, 100%)	Female (n = 1/3, 66.7%)

Table 2: Comparison of catheter malposition and corrected catheter.

AV: Axillary Vein; IJC: Internal Jugular Vein; TDV: Thoracodorsal Vein; VCS: Vena Cava Superior; SCV: Subclavian Vein.

The distribution of corrected catheter localization in neonates was mostly in the right axillary vein and more common in girls (75%) and at the superior vena cava (mostly girls), and subclavian vein (male n = 2, girl n = 1).

Discussion

PICC insertion is common in neonates requiring central venous access. PICCs have been used in the care of the critically ill neonates for over 30 years for TPN and fluid and medication administration. Before catheter placement, the catheter line length that needs to be inserted is estimated by measuring body surface markers, typically from the puncture point, traveling along the vein, passing the right sternoclavicular joint, and then traversing to the right third intercostal space. However, this length is only an estimate and cannot ensure the correct position of the PICC. The PICC location must be identified by imaging methods. X-ray is a traditional method to localize the PICC tip. It is applied in most institutes and known as the gold standard [13,14]. Particularly, digital portable X-ray can easily provide images to localize intravascular catheters while minimally disturbing the neonate. However, the minimal radiation effect is a disadvantage in X-ray. Contrast material was not used in our patients because X-ray provided sufficient images to evaluate the catheter tip and position.

Telang., *et al*. reported that ultrasound was useful in determining the catheter tip in 31 infants; however, they determined the location and position of the catheter using abdominal X-ray in two patients whose catheter position could not be evaluated with ultrasound [15]. Recently, target neonatal echocardiography has been used in the investigation of catheter malposition [16]. Echocardiography or ultrasonography was not required for PICC in our patients.

PICC related common complications include phlebitis, catheter malposition or migration, arrhythmia, line fracture, line embolization, accidental withdrawal, catheter malfunction/occlusion, catheter-related blood stream infections, leakage (such as pericardial or pleural effusion), and pneumothorax [5,16-17]. In our study, PICC malposition management was investigated, particularly in patients with catheter malposition. However, the complications in 221 patients without catheter malposition were not investigated.

Ren., *et al*. reported the rate of catheter insertion at the first attempt in 186 newborns as 93.5% [18]. PICC insertion success rate varies between 90% and 93% [19]. In our study, the rate of catheter placement at the first attempt was 91.7%, which was compatible with the literature.

Following catheter insertion, catheter malposition has been described in up to 20% of cases. Most of these catheters are in the internal jugular, external jugular, or brachiocephalic veins or curving on themselves in the subclavian or axillary veins. Rastogi., *et al*. found the rate of catheter malposition in the internal jugular, brachiocephalic, and subclavian veins as 3.7% in 187 infants [20]. The reported incidence of malposition without radiological guidance is approximately 10%, with internal jugular vein being the most common side, followed by axillary vein [21]. The catheter malposition rate in our study was 5.20%, which is compatible with the literature. Catheter malposition in the upper extremity was on the right (75%) and left (25%) in nine and three patients, respectively. Catheter malposition was seen on the right side of the axillary vein (n = 4), internal jugular vein (n = 3), thoracodorsal vein (n = 2), and on the left side of the axillary vein (n = 2) and internal jugular vein (n = 1). Catheter malposition being more common on the right side may be related to our preference of the right arm in catheter placement procedures.

Some pediatric studies found that PICC placed in non-central veins provided safe and reliable intravenous access [22]. Nevertheless, these studies cannot be easily compared due to inconsistent definitions of central veins. This study showed that the non-central PICC vein location can be used longer than the peripheral vascular access. Polyurethane PICC was more durable than silicone PICC, with a significantly lower incidence of complications, particularly phlebitis and catheter-related infections [23]. Despite best effort, PICC tips may not start, or stay, in a central location. Therefore, the possibility of catheters in the central location entering the heart and creating a life-threatening situation is quite higher than the non-central type location. None of our patients implanted with PICC had cardiac complications.

Our study is limited because of its single center and retrospective nature, and other catheter complications cannot be included. Additionally, catheter malposition was evaluated with radiographs, and no any other modalities (such as ultrasonography or echocardiography) were used for confirmation.

Conclusion

PICC is a relatively simple, but effective form of central venous access, particularly in the NICU. However, PICC must be carefully managed from insertion to removal. After the appropriate repositioning technique is applied in patients with malposition, the catheter can be made available, thus reducing the use of a larger number of catheters, reducing costs, and reducing repetitive peripheral vascular interventions.

In this study, we showed that the catheter can be safely used without complications when its tip is between the superior vena cava and axillary vein. However, studies with larger series need to be conducted.

Funding

None.

Competing Interest Statements

The authors declare that there is no conflict of interest.

Details of Ethics Approval

The study was approved by the Tekirdağ Namık Kemal University faculty of medicine ethics committee (protocol number: 2020.185.07.18).

Authors' Contributions

ST conceived the original idea and supervised the work. ST and HS collected and analysed the data, and took the lead in writing the manuscript as well. ST and HS provided critical feedback and contributed to the final manuscript.

ST was in charge of overall direction. Finally all authors have received and approved the final version of the manuscript as submitted.

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