

The Complications Caused by Peripherally Inserted Central Catheters and Related Risk Factors in Preterm Infants Admitted to the NICU

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ABSTRACT

Background: Central venous catheter placement through a peripheral vein is considered a valuable care strategy for infants with low and very low birth weight but it can be associated with complications. This study aimed to determine the incidence of complications arising from central venous catheter placement through peripheral veins in premature infants admitted to the neonatal intensive care unit (NICU) and to identify related risk factors.

Methods: This cross-sectional study was conducted on 323 premature infants with central venous catheters placed through peripheral veins who were admitted to the NICU of Shahid Sadoughi Educational Hospital in Yazd. Data were collected from March 2021 to March 2024 through the completion of a checklist assessing the catheter placement site by the nurse responsible for caring for infants during each shift. parametric and non parametric data analysis using SPSS software version 16.

Results: The mean gestational age and birth weight were 30.7 ± 2.83 weeks and 1391.63 ± 467.47 grams, respectively. Besides, 27.2% of the premature infants with catheters experienced complications. The most common complications in order of frequency were phlebitis (6.2%), catheter occlusion (4%), and leakage of secretions (4%), while bloodstream infection had the lowest occurrence rate (0.9%). In the univariate logistic regression model, the likelihood of complications increased by 1.02 times for each additional day of NICU stay and was 4.6 times higher with improper catheter positioning.

Conclusion: Continuous monitoring of the catheter insertion site for the occurrence of visible complications and the catheter's positioning should be prioritized in care. Moreover, the number of days of hospitalization could be reduced by improving the quality of treatment processes and nursing care.

Keywords: Catheter-related complication, Factors, Neonatal intensive care unit, Peripherally inserted central catheters, Preterm infants

Introduction

The secret to the survival of the human race lies in safe and healthy birth. Any infant born before 37 weeks of pregnancy is called a preterm infant (1). Every year, about 13 million premature births occur worldwide (2), and these infants

need care and support to breathe, feed, fight against infection, and keep warm (3). Thus, the admission of preterm infants to the NICU immediately after birth is inevitable (4), and during the NICU stay, such infants frequently

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need vascular access for a long time so that they can receive intravenous nutrition and drugs through this route. Hence, maintaining the venous path is considered vital (5). Utilizing the umbilical vein for long-term vascular access is one of the commonly used methods but the prematurity-related complications restrict the use of this technique (6).

Moreover, the complexity of the treatment and the length of the treatment process makes these infants extremely vulnerable (7). For this reason, the use of peripherally inserted central catheter (PICC) is considered a good option, so 8.3%-33% of preterm infants admitted to the NICU need peripherally inserted central catheter (8).

The peripherally inserted central catheter (PICC) was first introduced in 1970 as a device for providing intravenous nutrition. After entering a peripheral vein located in the hand, this catheter can be moved forward so that the tip of the catheter enters the superior or inferior vena cava (9, 10).

PICC is considered one of the valuable care measures in very low birth weight infants, as it provides a path for intravenous nutrition and administering various drugs and hyperosmolar solutions (11). PICC as a safe, convenient, and reliable method makes it possible to provide nutrition, ensure the timely administration of the drugs needed by the infant (12), increase the chances of survival (13), and increase the quality of life of premature infants (14). Besides, compared to other vascular access techniques, PICC has a higher success in placement and a lower risk of infection (15).

Nevertheless, despite its benefits, PICC can be associated with some complications that occur during the insertion of the catheter, the length of time the catheter remains in place, or after the catheter is removed. However, compared to the complications caused by other vascular access catheters, PICC is associated with fewer complications (16).

Some reported complications caused by PICC are pleural and pericardial effusion, cardiac tamponade, obstruction, thrombosis, sepsis, catheter movement, catheter fracture, phlebitis (17), and intracranial bleeding following repeated attempts to enter the catheter (18). The prevalence of PICC-related complications has been reported as 27%-42% (19) and the variation in complications can be caused by the difference in the characteristics of infants, including their weight and clinical conditions, or the catheter characteristics such as the size of the catheter (20).

Furthermore, several risk factors related to catheter-related complications have been identified, such as catheter retention for more than 5 days, predisposing conditions related to the infant, such as previous vein extraction, history of leakage, use of infusion bombs, the infant's young age (21), the use of arm or ankle flexion for venipuncture (22), prematurity, the severity of clinical conditions (23), the position of the catheter tip (14), the location of the catheter (24), and potential risk factors such as the clinical diagnosis of the infant, type of catheter, and prescribed intravenous treatments that need further investigations (25).

In total, several retrospective, prospective, and descriptive-cross-sectional studies have addressed the complications caused by PICC in premature infants and have identified different risk factors for the complications (26-30). Thus, an investigation of PICC-related complications is necessary in every care setting and can provide useful information for nurses to design safe care methods to prevent or minimize the incidence of complications (31, 32) and prevent unplanned catheter withdrawal (33). Indeed, nurses play a very important role in catheter insertion, catheter retention, diagnosis, and treatment of catheter complications, and increasing the knowledge of nurses in this field will lead to providing evidence-based care (34). To Given the significance of this issue and since a review of the literature revealed no study in Iran has yet focused specifically on examining central venous catheter placement through a peripheral vein in preterm infants, the present study aims to identify the complications caused by PICC and related risk factors in preterm infants admitted to the NICU.

Methods

Study Design, Setting, Sampling

This cross-sectional study was conducted in the NICU of Shahid Sadoughi Hospital in Yazd from late March 2021 to late March 2024. The research population consisted of all premature infants admitted to the NICU with peripherally inserted central catheter (PICC). Given a 95% confidence interval, the 16% estimated incidence rate of PICC-related complications from a similar study (31), and the error level of 0.04 and considering the probable 10% dropout, the sample size in this study was estimated to be 323 persons.

The criteria for the inclusion of infants in the study were preterm infants with a fetal age of 26-36 weeks and six days, having PICC, infants whose

catheter was placed after the first 24 hours of birth and had stable physiological conditions, and infants whose catheter was placed in the NICU by a nurse trained and approved by the hospital. The exclusion criteria were preterm infants with PICC who had congenital anomalies such as neural tube, digestive, and heart defects, the death of the infant, transfer of the infant to another hospital, and infants needing exchange transfusion during the study.

The researcher went to the parents of infants who met the requirements for inclusion in the study, provided some instructions about the objectives of the study and the research procedure, and obtained written informed consent from the parents. All central venous catheters were placed through the peripheral vein according to the standard catheterization protocol by a trained head nurse who was responsible for catheterization in the NICU of Shahid Sadoughi Hospital, Yazd. Six nurses were involved in assessing the catheters including one head nurse and five nurses in charge of evening and night shifts. Before starting the study, ten infants with catheters were evaluated by the nurses using the relevant checklist to assess inter-rater reliability, which was reported as 0.78 using the intraclass correlation coefficient.

The researcher arranged a coordination meeting with the head nurse to inform the nurses about the objectives of the study, how to carry it out, and the catheterization complication assessment checklist. The checklist was completed by the nurses during each work shift by checking the catheterization site based on the observation of completion and the head nurse of the NICU was responsible for collecting the checklists daily. The catheterization manager in the morning shift, the head nurse, and in the evening and night shifts, the nurse in charge of the shift controlled and checked the catheters and completed the checklist. The complications assessment checklist was completed daily from the time of catheter placement to the time of catheter removal.

Questionnaire and Data Collection

The data in this study were collected through a demographic information form, a catheterization information form, and a catheterization complication assessment checklist. The demographic information form assessed the infants' age at birth, gender, weight at birth, length of stay in the NICU, and clinical diagnosis of the infant. The catheterization information form assessed the specifications related to the inserted

catheter, including the location of the catheter (veins in the upper limb, the lower limb, the neck, and the head), the number of inserted catheters, the number of attempts to enter the catheter, the position of the catheter tip immediately after the catheter was inserted (an echocardiogram was used to determine the position of the catheter tip in the upper limb and radiography was used for the position of the catheter tip in the lower limb), and the materials received through the catheter (medicines, intravenous nutrition, and blood products).

The catheterization complication assessment checklist examined the following cases: The nurse in charge of checking the catheter used a three-part checklist. The completion of the checklist for each infant began with an observation of the catheter insertion site and continued until the catheter was removed. It is worth noting that the designed checklist was developed based on a review of the literature by the research team.

The first part assessed physical complications, the second part was intended to evaluate mechanical complications, and the third assessed circulatory system infection.

1. Physical complications: Phlebitis (vein inflammation with manifestations of pain, redness, swelling, and a palpable venous path), bleeding, purulent secretions at the insertion site, swelling in the arm, neck, or chest, and clear secretions at the insertion site.

2. Mechanical complications: Improper position of the catheter tip, displacement of the catheter, breakage of the catheter, and blockage (immediately after catheterization, the condition of the catheter was checked by radiography, and the improper position of the tip of the catheter, displacement of the catheter, and breakage of the catheter were checked and recorded by nurses. The occurrence of blockage due to lack of flush in the catheter following the formation of blood sediments and resistance to the injection medium (if any) was checked and recorded by a nurse).

3. Circulatory system infection: To check for circulatory system infection, a blood culture sample was taken from all preterm infants admitted to the NICU before catheter insertion for initial evaluation of the presence of infection. During the period when the catheter was not removed, in the event of a manifestation based on which the neonatologist suspected the presence of a circulatory system infection, a blood sample of 3 cc from the upper limb was taken according to the blood collection protocol and was sent for blood culture. The blood sample was examined in a

blood culture medium (Becton Dickinson Company).

The collected data were analyzed with SPSS-16 software. Data were presented as mean plus standard deviation or mean rank. The normal distribution of the data was checked and confirmed with the Kolmogorov-Smirnov test ($p > 0.05$). Parametric tests, including the independent samples t-test, were used for normally distributed continuous variables. For non-normally distributed data, the Mann-Whitney U test was applied and the differences between categorical variables were analyzed using the chi-square test and Fisher's exact test. Moreover, univariate and bivariate logistic regression analyses were used to determine risk factors.

Ethical approval

The protocol for this research project was approved by the Maternal and Infant Health Research Center of Shahid Sadougi University of Medical Sciences with the code of ethics IR.SSU.SPH.REC.1399.248.

Results

The mean fetal age of the infants was 30.69 ± 2.81 weeks. Out of 323 infants assessed in the study, 158 infants (48.9%) were female and 165 infants (51.1%) were male. The mean birth weight was 1391.63 ± 467.47 grams, the mean

length of stay in the NICU was 32.73 ± 21.74 days, and the mean number of days the catheter remained in place was 19.7 ± 15.64 days. The clinical diagnosis of the infants showed that 255 infants (78.9%) were hospitalized only because of prematurity and there was no other medical condition except for prematurity (Table 1).

The most frequent vein catheterization location was the upper extremity accounting for 197 cases (61%), catheter size for 280 infants (86.7%) was one French (0.33 mm), catheter tip position immediately after catheter placement was suitable for 315 infants (97.5%), the number of attempts for inserting catheter for 243 infants (75.2%) was once, and the reason for catheter exit was complications for 88 infants (27.2%). Most of the substances prescribed through the catheter for 187 infants (57.9%) were antibiotics, intravenous nutrition, and other drugs (Table 1). In general, 88 infants (27.2%) suffered from complications caused by catheter insertion. Of the 323 infants examined in this study, 57 infants (17.6%) had physical complications, 28 infants (8.7%) had mechanical complications, and 3 infants (0.9%) had circulatory infections. The most frequent physical complication was phlebitis observed in 20 preterm infants (6.2%) and the most frequent mechanical complication was catheter blockage found in 13 infants (4%) (Table 2).

Table 1. The descriptive statistics for the research variables

Variable	Categories	Catheter-related complications		P-value
		Yes	No	
Gender	Female	46 (29.11%)	112 (70.9%)	0.732 ¹
	Male	42 (24.45%)	123 (74.5%)	
Fetal age	< 28 weeks	9 (18%)	41 (82%)	0.708 ²
	28-33 weeks	62 (28.7%)	154 (71.3%)	
	34-36 weeks	17 (29.82%)	40 (70.2%)	
Catheter location	Upper limb vein	50 (25.4%)	148 (74.6%)	0.206 ²
	Lower limb vein	19 (24.4%)	59 (75.6%)	
	Neck vein	5 (33.3%)	10 (66.7%)	
	Head vein	14 (43.8%)	18 (56.3%)	
Catheter size	1 Fr	79 (28.2%)	201 (71.8%)	0.318 ¹
	2 Fr	9 (20.9%)	34 (79.1%)	
Location of the catheter tip	Suitable	83 (26.3%)	232 (73.7%)	0.023 ¹
	Unsuitable	5 (62.5%)	3 (37.5%)	
Number of attempts for catheterization	1	60 (24.7%)	183 (75.3%)	0.066 ¹
	2	15 (28.3%)	38 (71.7%)	
	3	6 (42.9%)	8 (57.1%)	
	More than 3	7 (20.9%)	6 (42.9%)	
Catheter prescriptions	Antibiotics and intravenous nutrition	43 (31.6%)	93 (68.4%)	0.132 ¹
	Antibiotics, intravenous nutrition, and other drugs	45 (24.1%)	142 (75.9%)	

¹ Chi-square test; ² Fisher's exact test

Table 2. The frequency of catheter-related complications

Catheter-related complications	Type of complication	Frequency	%
Physical complications	Arm and neck inflammation	15	4.6%
	Bleeding	9	2.8%
	Phlebitis	20	6.2%
	Clear secretions	13	4.0%
Mechanical complications	Catheter blockage	13	4.0%
	Catheter breakage	7	2.2%
	Catheter displacement	8	2.5%
Blood circulation infections		3	0.9%
Complications	Yes	88	27.2%
	No	235	72.8%

A comparison between the frequency of occurrence of complications in terms of normally distributed variables using the Chi-square statistical test showed no significant difference in the frequency of complications according to the catheter location (p-value = 0.2), catheter size (p-value = 0.3), age at birth (p-value = 0.7), infant gender (p-value = 0.7), the number of attempts for catheter insertion (p-value = 0.06), and substances administered (p-value = 0.1). However, there was a significant difference between the frequency of complications in terms of the position of the catheter tip after placement (p-value = 0.02). (Table 3).

Moreover, a comparison of the frequency of complications in terms of variables with non-normal distribution showed a significant difference between the frequency of complications

in terms of the average length of stay in the NICU (p-value <0.001), so that the complications were more frequent in premature infants who stayed for a longer time in the NICU. However, there was no significant difference in the complications in terms of the number of days the catheter remained in the site (p-value = 0.06) and the infant weight (p-value = 0.6) (Table 4).

The data from the univariate logistic regression model for all the studied variables (predictor variables) showed that the "length of stay in the NICU" and "catheter tip position after catheter placement" were significant variables in the univariate logistic regression model. For the variable length of stay in the NICU, the OR value was equal to 1.028 (p<<0.001), showing that for an additional day of stay in the NICU, the probability of causing complications from catheter

Table 3. The frequency of catheter-related complications by normally distributed variables

Variable	Categories	Catheter-related complications		P-value
		Yes	No	
Gender	Female	46 (29.11%)	112 (70.9%)	0.732 ¹
	Male	42 (24.45%)	123 (74.5%)	
Fetal age	< 28 weeks	9 (18%)	41 (82%)	0.708 ²
	28-33 weeks	62 (28.7%)	154 (71.3%)	
	34-36 weeks	17 (29.82%)	40 (70.2%)	
Catheter location	Upper limb vein	50 (25.4%)	148 (74.6%)	0.206 ²
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Catheter size	1 Fr	79 (28.2%)	201 (71.8%)	0.318 ¹
	2 Fr	9 (20.9%)	34 (79.1%)	
Location of the catheter tip	Suitable	83 (26.3%)	232 (73.7%)	0.023 ¹
	Unsuitable	5 (62.5%)	3 (37.5%)	
Number of attempts for catheterization	1	60 (24.7%)	183 (75.3%)	0.066 ¹
	2	15 (28.3%)	38 (71.7%)	
	3	6 (42.9%)	8 (57.1%)	
	More than 3	7 (20.9%)	6 (42.9%)	
Catheter prescriptions	Antibiotics and intravenous nutrition	43 (31.6%)	93 (68.4%)	0.132 ¹
	Antibiotics, intravenous nutrition, and other drugs	45 (24.1%)	142 (75.9%)	

Table 4. The frequency of catheter-related complications by non-normally distributed variables

Variable	Catheter-related complications	Mean rank	P-value
Length of stay in the NICU	No	146.37	< 0.001 ¹
	Yes	203.74	
Number of days the catheter remained in place	No	167.93	0.062 ¹
	Yes	146.17	
Fetal age	No	163.35	0.671 ¹
	Yes	158.40	

¹ Mann-Whitney U test

insertion would be equal to 1.028, and the OR value for the suitable position of the catheter tip after the placement was 4.659 ($p < 0.035$), suggesting that the complication rate in the inappropriate position of the catheter tip would be 4.659 times higher than in the appropriate

position (Table 5).

Finally, adding two significant variables from the univariate regression model into the multivariable regression model showed that the significant variable in this model is "length of stay in the NICU" (OR = 1.027; P-value < 0.001) (Table 6).

Table 5. Univariate logistic regression analysis

Variable	Categories	B	Sig.	OR	95% CI for OR		Omnibus Test
					Low	High	
Fetal age (week)		0.038	0.391	1.039	0.952	1.134	0.390
Gender	Male			1			0.460
	Female	0.185	0.461	1.203	0.737	1.964	
Birth weight (g)		0.000	0.554	1.000	0.999	1.000	0.551
Length of stay in the NICU		0.028	<0.001	1.028	1.016	1.040	<0.001
Location of the catheter tip	Suitable			1			0.035
	Unsuitable	1.539	0.038	4.659	1.089	19.923	
Number of days the catheter remained in place		-0.006	0.493	0.994	0.978	1.011	0.478
Clinical diagnosis	Prematurity			1			0.360
	NEC	1.429	0.227	4.444	0.394	50.074	
	RDS	-0.523	0.224	0.593	0.255	1.377	
	Sepsis	-0.668	0.312	0.513	0.140	1.874	
	IUGR	-0.706	0.377	0.494	0.103	2.363	
	Prematurity and multiple births	-0.545	0.133	0.580	0.284	1.181	
Catheter location	Upper limb vein			1			0.232
	Lower limb vein	-0.055	0.860	0.947	0.515	1.740	
	Neck vein	0.385	0.500	1.470	0.479	4.507	
	Head vein	0.827	0.035	2.278	1.060	4.932	
	Upper limb and neck vein	-20.124	1.000	00.000	0.001		
Catheter size	1 Fr			1			0.307
	2 Fr	-0.395	0.320	0.673	0.309	1.468	
Number of attempts for catheterization	1			1			0.090
	2	0.186	0.584	1.204	0.619	2.341	
	3	0.827	0.140	2.287	0.763	6.858	
	More than 3	1.269	0.028	3.558	1.151	11.001	
Catheter prescriptions	Antibiotics and intravenous nutrition			1			0.11
	Antibiotics, intravenous nutrition, and other drugs	-0.378	0.133	0.685	0.419	1.122	

Table 6. Multiple logistic regression analysis

Variable	Categories	B	Sig.	OR	95% CI for OR		Omnibus Test
					Low	High	
Length of stay in the NICU		0.027	<0.001	1.027	1.015	1.039	<0.001
Location of the catheter tip	Suitable			1			
	Unsuitable	1.081	0.171	2.948	0.627	13.863	

Discussion

Overall, the findings of this study suggested that 27.2% of premature infants suffered from complications caused by catheter placement. A study by Wu et al. (2022) showed that of 519 infants admitted to the NICU with catheters, 72 infants (13.12%) had complications, which was less than the rate of complications reported in the present study. This difference can be to some extent due to the age group of the studied infants. Wu et al. examined infants aged 23 to 39 weeks (35) and there was no distinction between preterm and full-term infants. However, the present study examined premature infants with an age of less than 37 weeks.

Gavelli and Wackernagel (2021) reported that out of 188 infants with catheters, 48 infants (26%) had complications, and the frequency of complications was close to the frequency of the complications reported in the present study possibly due to the age of the infants. In the mentioned study, 87% of premature infants were aged 28 weeks or less (36).

A comparison of physical complications indicated that the most common complications were phlebitis, swelling, leakage, and bleeding in order of frequency. Wu et al. (2022) reported phlebitis (71.7%), improper catheter position (3.66%), leakage (1.35%), pleural effusion (1.15%), and circulatory infections (0.58%) as the most frequent catheter-related complications (35). Moreover, Cheong et al. (2016) found that the incidence of phlebitis in infants with low birth weight was 12% (37). Consistent with these findings, the present study reported phlebitis as the most frequent catheter-related complication, indicating that phlebitis is the main cause of mechanical irritations (38).

The present study showed that the most common mechanical complications were catheter blockage, catheter displacement, and catheter breakage. In line with this finding, a retrospective study by Razavinejad et al. (2023) showed that catheter obstruction was one of the most important complications identified in infants with a fetal age of over 24 weeks (39). In addition, a retrospective study by Pet et al. (2020) showed that the frequency of this complication was 2.6% (40). Padilla-Sánchez et al. (2019) reported a prevalence of 5.7% (41) and Xiaohe Yu et al. (2018) reported the frequency of catheter obstruction to be 3% (42).

Blood circulation infection was another catheter-related complication identified in the present study, accounting for 0.9% of preterm

infants undergoing catheterization. A review of the literature showed that the incidence of bloodstream infection has been reported in different studies. For instance, a study by Hosseini et al. (2014) in Tabriz showed that circulatory infection was 14% (43), Tomar et al. (2020) reported an incidence rate of 3.3% in India (44), Pet et al. (2020) reported a rate of 1.4% in Washington (40), and Padilla-Sánchez et al. (2019) reported an incidence rate of 5.7% (41). This conflicting variation in blood circulation infection can be due to the sensitivity of infection diagnostic tests and also the quality of care of the center where catheterization was performed (39).

The data in the present study indicated that the mean length of stay in the NICU in premature infants with complications was 42.67 days, while it was 12.6 days in a study by Prado et al. (2020) (45). The difference between the number of days reported in this study and the present study can be attributed to the infants' age. Accordingly, in the aforementioned study, more than half of the infants undergoing catheterization had a fetal age of more than 32 weeks (45). Fu et al., 2023, in a systematic review study, suggested that weight, age, sepsis, necrotizing enterocolitis, bronchopulmonary dysplasia, and retinopathy of prematurity were effective risk factors in the long-term stay of premature infants in the NICU (46).

The present study showed that for one more day of stay in the NICU, the probability of complications caused by catheter insertion in infants increases by 1.028 times. Razavinejad et al. (2023) also suggested that the mean length of stay in the NICU increases the chance of complications of circulatory infection, so that for every one day of stay in the NICU, the chance of infection increases by 11%, and when infants stay in the NICU for 14 days, they are more likely to experience a complication (39).

However, the factors effective in increasing the length of stay in the NICU should also be taken into account. For instance, some factors such as fetal age, weight less than 2 kg, small size compared to fetal age, pneumonia (47), prematurity (48), insufficient staff expertise to provide care for premature infants (49), lack of job satisfaction and fatigue in nursing staff (50), and overwork and long working hours (51) can affect the length of stay in the NICU. Thus, the presence of the mentioned variables affects the length of stay in the NICU and the subsequent occurrence of complications.

The length of time the catheter remained in this study was 18.3 days. Purkayastha et al. (2017)

reported that the median time of the catheterization was 11 days (52) and Wu et al. reported 12.8 days (35). The difference in the length of time the catheter stays in the vein can be attributed to the fact that it is not clear how long the catheter remains in the vein. For instance, Sengupta et al. (2010) suggested since the catheter is inserted for short-term access, it should be replaced after 35 days (53), but Greenberg et al. suggested if the catheter is not infected, it should not be replaced (54). In contrast, Zingg et al. (2011) stated that catheter retention for more than 7 days leads to infection (55).

Concerning the location of catheterization, the present study indicated that 61% of the catheters were placed in the upper limb vein. Moreover, the nurse responsible for the catheterization succeeded in placing the catheter with only one attempt in 2% of the infants. In addition, a French-size catheter was used for most of the infants (86.7%) and after placement, radiography was performed to determine the correct placement of the catheter tip, and the catheter placement (in the superior vena cava or lower) was evaluated to be correct in the majority of infants (97.5%). Wu et al. (2022) reported that 89.4% of the catheters were placed in the veins of the upper limb (35).

Moreover, Gavelli and Wackernagel (2021) found that 41% of the catheters were placed in the vein of the left arm and 36% in the vein of the right arm (36). Razavinejad et al. (2023) reported that the upper limb was the most common place for catheterization so 43% of the catheters were placed in the median cubital of the upper limb (39). Carneiro et al. (2021) showed that the catheters were placed in the vein of the upper limb in 34.1% of infants. Generally, the veins of the upper limb are the most suitable place for catheter placement because they have a more favorable anatomy, a larger diameter, fewer valves, and a shorter path to reach the superior vena cava (56).

The present study found that the catheters were placed in the right position by a nurse with only one attempt for the majority of infants. Consistent with this finding, Uygun et al. reported that 86% of catheters were inserted with one attempt (64) and Njere et al. found that 71% of catheters were placed with one attempt (58). However, Purkayastha et al. (2017) showed that the catheters were placed successfully with two attempts for a majority of infants (52) and Njere et al. reported that 73.7% of catheters were placed with four attempts (58). These variations in

findings indicate that several factors such as medical staff's expertise in venipuncture, having good theoretical and practical knowledge about venous networks, receiving continuous guidance from the hospital's intravenous treatment committee, and catheter placement based on standard principles can all lead to providing a standard performance and maintaining patient safety during catheter placement (56).

The present study showed that 1-Fr catheters were used for most of the infants. Similarly, Razavinejad et al. reported that French-size catheters were used for all infants aged 24 weeks or older who underwent catheterization (39) as French-size catheters reduce the risk of mechanical irritation in small veins and using catheters with a larger size increases the possibility of long-term friction between the vascular wall and the catheter (35).

The findings of the present study concerning the (suitability/unsuitability) of the position of the catheter tip in the vessels using X-ray indicated that the majority of catheters were inserted in the right position, both in the upper and lower limbs, showing that the catheter tip was placed in the superior vena cava or the inferior vena cava. Likewise, Uygun et al. (2011) reported that 100% of the catheters were placed in the right position (57) and Njere et al. (2011) found that 72.8% of the catheters were inserted in a suitable position (58). Thus, it seems that the skill of the nurse in charge of catheterization plays a vital role in correct catheterization, and passing training courses and confirming the qualification of the nurse to perform catheterization can be a factor in preventing the complications caused by the improper position of the catheter tip.

The data from the univariate logistic regression analysis concerning the position of the catheter tip showed that the complication rate was 4.659 times higher when the catheter was placed in the incorrect position compared to the correct position. In a similar vein, Li et al. (2022) suggested that the inappropriate position of the catheter can increase the chance of phlebitis by 5.5 times (59). Razavinejad et al. (2023) introduced the improper position of the catheter and the duration of the catheter as a risk factor that increases the incidence of complications by 2.4 times (39). Moreover, Xiaohe et al. (2018) also identified the position of the catheter tip as an independent risk factor for non-selective catheter withdrawal (OR = 2.6) (30).

An analysis of the reasons for catheter withdrawal indicated that the mean reason for

catheter withdrawal in 27.2% of cases was the occurrence of complications. However, different studies have reported different rates. Purkayastha et al. (2017) reported that 20.1% of the catheters were removed due to complications (52), Uygun et al. (2011) reported 13% of catheter removals (57), Njere et al. (2011) reported 36.9% of catheter removals (58), Pet et al. (2020) reported 28.4% of catheter removals due to the occurrence of different complications (47) such as phlebitis, infection, and the unsuitable position of the catheter tip (43). Igarashi et al. (2021) reported that 34.5% of catheters were removed due to phlebitis (60) and Urkayastha et al. (2017) reported catheter removals due to complications such as blockage, catheter breakage, and organ swelling (52).

Concerning the reasons for catheter placement, the present study showed that 57.9% of catheters were inserted for prescribing antibiotics, intravenous nutrition, and other drugs. Accordingly, Wu et al. found that 99% of the neonates under catheterization had intravenous nutrition and 82.2% received antibiotics (35). Moreover, Purkayastha et al. (2017) (52) and Carneiro et al. 2021 (56) showed that 70.1% and 53.8% of infants underwent catheterization to receive intravenous nutrition. The prematurity of the immune system of premature infants can lead to susceptibility to infections, which creates the need for therapeutic support with antibiotics. In addition, stomach failure often prevents the start of enteral feeding and leads to the start of parenteral feeding (61). Furthermore, establishing a safe venous route for long-term treatment through central venous catheterization through peripheral access is a helpful method (63) and provides reliable vascular access (57).

The present study showed no statistically significant difference in the incidence rate of complications according to gender, weight, and age. In line with these findings, Wu et al. (2022) placed the infants into two groups according to weight of less than 1000 grams and 1000-1500 grams and found a significant difference in terms of the incidence of complications according to weight and gender (35). Pourhrastara et al. (2017) examined the incidence rate of complications according to the age of infants and showed the same rate of occurrence (52). Moreover, Varghese et al. (2021) found no significant relationship between the age and weight of infants with catheters with the incidence of complications (62).

This study was conducted with some limitations. For instance, the type of vein

(cephalic, basilic, saphenous, etc.) used to insert the catheter was not specified, and the location of the catheter was recorded only in the upper and lower limbs. Thus, it was not possible to analyze and compare the complications that occurred depending on the type of vein. Moreover, the checklists used in this study were completed based on the observations and reports provided by the nurses in each work shift, which may affect the reliability of the collected data and findings. Therefore, it is recommended that further studies employ more reliable data collection methods and examine catheter insertion sites with more details, particularly with respect to the type of extremity.

Conclusion

A strength of the present study is that it is the first study conducted in Iran to examine the complications related to catheterization in preterm infants, and the data obtained has provided basic knowledge for the treatment team, particularly for nurses, to enable timely evaluations and preventive interventions while delivering care with a focus on the factors influencing catheter position. Overall, the present study showed that the most frequent complication caused by peripherally inserted central catheter (PICC) was phlebitis, and the length of stay in the NICU and the unsuitable position of the catheter were found to be two predicted risk factors for the occurrence of complications. Hence, training nurses can improve the quality of catheter-related care, enhance the skills of nurses in catheter placement, promote the quality of treatment and care processes for preterm infants and their length of stay in the NICU, and reduce the incidence of catheter-related complications.

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Conflicts of interest

There are no conflicts of interest.

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