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A proposed equation estimating the length of peripherally inserted central catheter in hand for NICU hospitalized preterm neonates

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Abstract

Background: Although PICC plays a crucial role in preterm neonates, it may cause several complications. A pilot study was conducted to propose a useful equation in identifying the safe length of catheter during the first attempt of catheterization.

Methods: A pilot study was carried out and NICU admitted preterm neonates requiring PICC insertion entered the study. PICC was inserted for neonates by an expert NICU nurse. After catheterization, a chest X-ray examination with contrast was done to determine the location of canola. All neonates' demographic data were extracted from medical records. Age of neonate at catheterization, the duration of catheterization period as well as data regarding the first and final sizes of the inserted PICC were also recorded. Finally, the associations between the lengths of catheters with neonates' demographic factors were assessed to propose an equation estimating the optimal length of inserted PICC.

Results: One hundred preterm neonates requiring PICC entered the study. The results have shown significant associations between the first length of inserted catheter in the hand with head circumference (p=0.019; r=0.293) as well as the final length of inserted catheter in the hand with birth weight (p=0.015; r=0.304). There was a linear correlation between the length of inserted catheter in the hand with neonate's birth weight (p=0.029); however, based on the value of R^2=0.167, this relationship was weak. According to these findings an equation was proposed as follows; Inserted length in hand (cm) = 17.98 + 0.618body weight (gr).

Conclusion: Our results showed a positive correlation between the inserted lengths of PICC in the hand with neonate's body weight. Our findings proposed an equation; however, the regression coefficient was not significantly notable.

Keywords: Preterm; Neonates; PICC; Equation; Length

1. Introduction

A Peripherally inserted central catheter (PICC) is a silicone-made catheter that is inserted peripherally and guided into the central veins including the superior vena cava (before the right atrial junction) or the inferior vena cava (close to the diaphragm). PICC is commonly implemented for prolonged NICU (neonatal intensive care unit) hospitalized neonates to supply their nutritional and medical requirements [1, 2]. For insertion a PICC, firstly a steel 19 or 24-gauge

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butterfly needle is inserted into a peripheral vein then a 24 or 27-gauge silicone catheter passes through the needle until the tip of the catheter is places in the appropriate location [3].

PICC plays a crucial role in preterm neonates with requirements of parenteral nutrition and intravenous medications also in neonates with congenital gastrointestinal, respiratory or heart anomalies. PICCs on the other hand may cause several complications that result in significant morbidity and mortality. Ruptured PICC, inappropriate insertion site regarding the location of catheter tip, misplacement, repositioning the catheter are some of problems that can increase the risks of hemothorax, pneumothorax, sepsis, embolism, phlebitis, bleeding, intravascular thrombosis, extravasation of parenteral nutrition, or pericardial effusion with tamponade and even death [2, 4-6]. Moreover, the procedure associated with PICC insertion especially in preterm neonates with tiny vessels requires lots of skill [7].

To prevent such fatal complications or introducing a convenient procedure for PICC catheterization, an investigation by Chen et al. designed several equations to estimate the optimal insertion lengths at different body locations. By using the data related to 214 neonates with PICC, the authors have designed different formulas to estimate the safe insertion length of PICCs in the hand, foot, axillary, femoral and popliteal veins. According to these proposed equations, the inserted length of PICCs in the foot, axillary and femoral veins correlated to neonate's body weight also PICCs insertion in the hand and popliteal vein associated with body length. Moreover, the authors demonstrated a notable decrease in the adjusting rate of PICCs by 20% following use of these equations [5].

To the best of our knowledge, there has been no other study proposing the equation regarding the optimal length of inserted PICC in neonates. Therefore, a pilot study was conducted to propose a useful equation in identifying the safe length of catheter inserting in the proper site into the central vein during the first attempt of catheterization.

2. Methods

A pilot study was carried out at NICU of Yas Hospital (affiliated to Tehran University of Medical Sciences, Tehran-Iran) in 2020. NICU admitted preterm neonates with gestational age 24-36 weeks requiring PICC insertion entered the study. Gestational ages above 36 or below of 24 weeks as well as the death of neonates during the period of study were considered as exclusion criteria. All neonates' demographic data including sex, gestational age, birth weight, length, head circumstance, body mass index (BMI) and crown-heel length were extracted from medical records also recorded in a check list. PICC was inserted for neonates by an expert NICU nurse under sterile condition. The tip of the catheter was located into the superior or inferior vena cava. After catheterization, a chest X-ray examination with contrast (0.3 mL of Iopamidol containing iodine of 300 mg/mL) was done to determine the location of canola [8]. Based on the results of radiographic examination, the location of the catheter was ascertained by the neonatologist then its length was measured and recorded. Age of neonate at catheterization, the duration of catheterization period as well as data regarding the first and final sizes of the inserted PICC were recorded. Finally, the associations between the lengths of catheters with neonates' demographic factors were assessed to propose an equation estimating the optimal length of inserted PICC.

All parents of neonates signed an informed consent before entering the study. Our data were confidential and no extra cost was constrained on our participants. The study was approved by the Ethics committee of Tehran University of Medical Sciences and ethical (ID Number: IR.TUMS.VCR.REC.1398.679). As the present investigation was a pilot study, 100 preterm subjects were enrolled.

2.1. Statistical analysis

All statistical analyses were conducted using SPSS 19. Data were presented as mean±standard deviation for continuous variables and n (%) for categorical variables. The independent t-test was used for comparison of variables with normal distribution. Correlations between quantitative variables were assessed by Pearson correlation test. Linear regression test was also used to evaluate the influence of each factor on the length of inserted PICC. R^2 value as coefficient of determination was calculated to show the association between predicted values with the real data measures. Finally, all recorded data were analyzed to propose an equation to estimate the inserted length of PICC in preterm neonates. P value less than0.05 was considered statistically significant.

3. Results

One hundred (45 males and 54 females) preterm neonates requiring PICC entered the study. The means of gestational age, birth weight, length, and head circumference were 31.030±3.045 weeks, 1479.850±558.243 gr, 40.820±4.688 and 28.335±3.065 Cm, respectively. PICC catheterizations in the 4 cases were repeated. The majority of PICCs were placed

in the right side of the body (62.6%) and in the hand (64.6%). The means of duration of catheterization and age at catheterization were 16.102 and 9.42 days. Detailed data regarding the catheterization variables are shown in Table 1.

Analyses of data have shown no correlations between the length of catheter and neonatal anthropometric parameters (Table 2). Linear regression analyses also showed that there were no associations between the length of catheter and neonatal characteristics (Table 3).

Table 1 Descriptive data related to PICC insertion

Catheterization variables	Total (N=100)
Location of inserted catheter [Number (%)]	
Right side	62 (62.6)
Left side	37(37.4)
Leg	27 (27.3)
Popliteal vein	6 (6.1)
Jugular	2 (2)
Hand	64 (64.6)
Axillary	5 (5.1)
First Size (Cm; Mean±SD)	14.626±4.2404
Final Size (Cm; Mean±SD)	12.601±4.187
Duration of catheterization (Day; Mean±SD)	16.102±11.562
Age at catheterization (Day; Mean±SD)	9.42±14.271

Table 2 Associations between the first and final sizes of inserted catheter with neonatal parameters

Variables	First size of inserted PICC p value (r)	Final size of inserted PICC p value (r)
Gestational age	0.206 (0.129)	0.079 (0.178)
Birth weight	0.252 (0. 116)	0.127 (0.154)
Birth head circumference	0.091 (0.171)	0.191(0.133)
Birth length	0.618 (0.051)	0.599 (0.054)
Age at catheterization	0.299 (-0.105)	0.127 (-0.154)

As the length of inserted catheter entirely correlated to the location of catheterization, the data related to the catheter and the place of insertion were analyzed. But because of very limited data associated with catheterization in the popliteal, jugular and axillary veins, only PICC insertion in the hand (64 cases) and in the leg (27 cases) were evaluated (Table 4). The results have shown significant associations between the first length of inserted catheter in the hand with head circumference (p=0.019; r=0.293) as well as the final length of inserted catheter in the hand with birth weight (p=0.015; r=0.304) (Table 5). The results of Linear regression analysis determining the possible equation between length of inserted catheter and other neonatal parameters have shown a linear correlation between the length of inserted catheter in the hand with neonate's birth weight (p=0.029) (Table 6). However, it should be noted that based on the value of R^2=0.167, this relationship was weak. According to these findings an equation was proposed as follows; Inserted length in hand (cm) = 17.98 + 0.618body weight (gr). On the other hand, there were not any significant correlations or linear associations between the lengths of inserted catheter in the leg with neonate's parameters. So, no equation could be extracted regarding the length of catheter inserting in the leg (Tables 5, 6).

Table 3 Associations between length of inserted catheter and neonatal characteristics (Linear regression)

variables	Unstandardized Coefficients		Standardized Coefficients	t	95,0% Confidence Interval for B		p value
	B	Std. Error	Beta		Lower Bound	Upper Bound	
GA	0.225	0.241	0.164	0.934	-0.253	0.703	0.353
Weight	0.001	0.002	0.200	0.827	-0.002	0.005	0.411
Head	0.119	0.291	0.087	0.409	-0.460	0.698	0.684
length	-0.278	0.169	-0.311	-1.641	-0.613	0.058	0.104
Age at catheterization	-0.040	0.030	-0.138	-1.369	-0.099	0.018	0.174

Table 4 Descriptive data related to PICC in hand and leg

Variables	PICC in hand (Mean± Std.)	PICC in leg (Mean± Std.)
Gestational age (weeks)	31.171±3.155	31.038±2.849
Weigh (gr)	1523.437±581.106	1402.963±479.076
Head circumference (Cm)	28.492±3.142	28.148±2.841
length (Cm)	40.929±4.358	40.592±5.032
Duration of Catheterization (Day)	15.857±11.929	14.615±10.994
Age at catheterization (Day)	8.64±12.293	5.63±8.413
First size (Cm)	14.359±3.395	17.092±4.323
Final size (Cm)	12.132±3.000	15.481±4.724

Table 5 Correlations between lengths of inserted catheters in the hand and leg with neonate's variables

PICC in hand		
Variables	**First size of inserted PICC p value (r)**	**Final size of inserted PICC p value (r)**
Gestational age	0.428 (0.101)	0.162 (0.177)
Weight	0.074 (0.225)	0.015 (0.304)
Head circumference	0.019 (0.293)	0.065 (0.232)
length	0.422 (0.102)	0.408 (0.105)
Age at catheterization	0.155 (0.180)	0.327 (0.124)
PICC in Leg		
Gestational age	0.159 (0.285)	0.127 (0.307)
Weight	0.338 (0.192)	0.318 (0.200)
Head circumference	0.398 (0.169)	0.417 (0.163)
length	0.278 (0.217)	0.348 (0.188)
Age at catheterization	0.513 (-0.132)	0.575 (-0.113)

Table 6 Correlations between catheter lengths in hand and leg with neonatal characteristics (Linear regression)

Variables	Standardized Coefficients	95,0% Confidence Interval for B		P value
	Beta	Lower Bound	Upper Bound	
Hand				
GA	-0.093	-0.488	0.312	0.661
Weight	0.618	0.000	0.006	0.029
Head length	0.061 -0.353	-0.381 -0.531	0.498 0.044	0.791 0.096
Age at catheterization	0.150	-0.023	0.096	0.222
Leg				
GA	0.252	-0.900	1.673	0.538
Weight	-0.126	-0.299	0.170	0.573
Head	0.627	-.0.007	0.180	0.345
length	-0.292	-0.274	1.853	0.691
Age at catheterization	-0.279	-0.165	0.690	0.599

4. Discussion

Using an accurate equation before the PICC catheterization to estimate the optimal length may prevent catheter misplacement, repositioning, adjustment and repeating the procedures that could notably decrease the risks of severe or fatal complications**.** Furthermore, the repeated failure in skin punctuation and catheter insertion creates lots of pain in preterm neonate and also causes a significant stress for the NICU nurses. Up to our knowledge, there is only one investigation that calculated an equation, indemnifying the optimal inserted PICC length in neonates. Therefore, it seems conducting further studies to confirm previous results or suggest new equations are crucial.

The results of our pilot study showed that the majority of PICC lines were placed in the hand compared to in the leg (64.6% vs. 27.3%). Although we did not evaluate and compare the risk of complications related to PICC catheterization in the hand and leg among our subjects, these findings indicate the preference of our NICU nurses for hand catheterization**.** In accordance with our findings, Bashir et al. reported that 72% of 827 included preterm neonates had PICC insertion in their upper extremity [9]. On the contrary to our results, it has been demonstrated that the first preference vein for the PICC insertion could be saphenous vein in lower extremity at the ankle because of its length, large diameter, stabilization, easy catheterization and access to the vena cava [10]. Karapinar et al. indicated that although femoral, internal jugular and subclavian veins are the most common sites for PICC insertion, the highest success rate of catheterization was associated with the femoral vein [11]. Moreover, it was reported that the possible complications associated with lower limbs catheterization are not life-threatening when compared with complications related to upper limbs catheterization [5].

The results of the present study proposed an equation that showed Inserted length of PICC in the hand equals to 17.98 + 0.618body weight (gr). But because of low regression coefficient (R^2=0.167), it was found that this relationship was weak. In addition, according to the findings there were no linear associations between the lengths of inserted catheter in the leg with neonate's parameters. It seems that differences in neonates' anthropometric characteristic, body size, sex, or puncture point in the hand or leg may be involved in such results. Moreover, our sample size was too small to design accurate and applicable equations for estimating the length of inserted PICC in various locations and different sexes. Further studies with larger sample size could beneficially provide data for designing accurate equations. In contrast to our results, Chen et al. demonstrated a significant association between inserted length of PICC in the hand with body length by following equation; length of PICC in hand= 4.46+ 0.32× body length (cm), with R^2 value 0.815. The authors declared that the regression coefficient related to the PICC inserted in the hand was lower than these values

related to poplitea(0.937) or femoral (0.967)veins. They suggested that these differences may correlate to the fewer participants with PICC in the hand and the differences in the distance from the right or left hand to the vena cavas [5]. A retrospective study by Jeon et al. also calculated formulas to estimate the length of PICC insertion in upper arm veins in 165 20-89 years old male and female adult patients. The authors showed that regardless of location of inserted veins (in basilic, cephalic, or brachial veins) or participant's sex, Elbow crease to carina length (ECL) was significantly correlated with case's height and weight by these mentioned formulas;

ECL for estimating the optimal length of PICC= height 0.192 + 14.435; $R2$ =0.293 and ECL for estimating the optimal length of PICC= height 0.157 + weight 0.046 + 17.380; R^2 =0.336 [12].

Our study had several limitations. First, our sample size was small with very limited data regarding PICC insertion in the hand, leg and particularly in the poplitea, femoral and jugular veins. We did not analyze our data based on different sex or race that may strongly influence neonate's anthropometric parameters. Finally, we did not assess and compare the complications based on the sites of PICC insertion. Further studies with larger sample size and more variables are strongly suggested.

5. Conclusion

Our results showed a positive correlation between the inserted lengths of PICC in the hand with neonate's body weight. Although our findings proposed an equation, the regression coefficient was not significantly notable. Further studies with larger sample size may design accurate equations determining the optimal insertion length of PICC before catheterization procedure.

Compliance with ethical standards

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The datasets related our study is available from the corresponding author on reasonable request.

Disclosure of conflict of interest

Dr. MRZ and Dr. MK carried out the design and coordinated the study, participated in most of the experiments. Dr. MSA, MR and Mrs. MH coordinated and carried out all the experiments, and analysis of data. All authors participated in manuscript preparation. All authors have read and approved the content of the manuscript.

Statement of ethical approval

Our study was approved by the institutional review board of Tehran University of Medical Sciences and according to Helsinki declaration. All participants' parents of the minors included in this study gave written consent before enrollment. Participants' data were considered confidential and no extra cost was imposed on our participants.

Statement of informed consent

Written informed consent was obtained from the patient's legal guardian for publication of this study.

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