

Assessment of the Complications of Peripherally Inserted Central Catheter in Neonates Admitted to the Intensive Care Unit: A Center's Experience in Iran

Abstract

Background: Peripherally Inserted Central Catheter (PICC), which is inserted through peripheral veins into the superior or inferior vena cava, is used to inject medications or parenteral nutrition in neonates with long-term hospitalization in the intensive care unit. In this study, we assessed the complications of PICC in neonates admitted to the intensive care unit in hospital. **Materials and Methods:** In the present retrospective cohort, neonates admitted to the Neonatal Intensive Care Unit (NICU) of Valiasr Hospital during 2015-2018 had been divided into two groups with PICC and without it. Data included the occurrence of septicemia, tachycardia, perforation of large veins, pulmonary hypertension, cardiac tamponade, pericardial effusion, catheter site necrosis, hemorrhage, anemia, pleural effusion, ascites, phlebitis of catheter track and neonatal death, which were collected, using the comprehensive neonatal registry of Valiasr Hospital. Data analysis was performed with regression, mantel-haenszel and independent *t*-test. **Results:** Data from 174 neonates with PICC were compared to 207 infants with classic IV-Line. In the exposure group, the gestational age and birth weight were lower. Based on the results of the double logistic regression test, septicemia and hemorrhage in the injection site, independent of other variables, were related to the use of PICC and the risk of septicemia or hemorrhage in the injection site was significantly reduced if PCIC was used ($p < 0.01$). **Conclusions:** Using the PICC as a therapeutic procedure in hospitalized neonates in the NICU is a safe method. By improving its replacement skills among physicians and nurses, its side effects are minor and negligible.

Keywords: Catheterization, intensive care unit, neonatal nursing

Introduction

A Peripherally Inserted Central Catheter (PICC) is made of silicone that is emplaced through peripheral veins inside the large veins present in the upper or lower limbs, scalp, or neck to be sent to vena cava vein. The PICC can be used to inject medications or parenteral nutrition in patients with long-term hospitalization that is difficult to access their arteries or the ones who can't be a cut-down candidate. Infants who are admitted in the Neonatal Intensive Care Unit (NICU) with less than 1,500 grams weight or the ones who have complex anomalies in gastrointestinal or cardiovascular system, as well as neonates who are unable to receive enough calories through the digestive tract for a long time, and those who are expected to receive intravenous injections for at least 7 days, and in any case that is required to access to the central vein, it seems to be less risky to use the PICC compared to a central venous catheter that is

inserted directly, and it is recommended in documents.^[1] Despite the widespread usage of the PICC in neonatal nursing, there are side effects associated with it that detection of them will be lead to the prevention and reduction of these complications. Consequences such as perforation of arteries during emplacement, phlebitis, cardiac arrhythmia, nerve damage, blockage of the flow path in the catheter, hemorrhage, infection, clot formation and obstruction, thrombosis of superficial and deep veins, misplaced catheter and its displacement, air embolism and catheter embolism after its replacement, have been reported.^[2]

The two groups of studies were conducted in support of IV-line or PICC, respectively. In the first category studies, a significant relationship was found between the emplacement location of the catheter and its duration with the occurrence of infectious and mechanical complications,^[3-5] although in

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opposite studies such a result was not achieved^[6,7] and even the results of some recent studies support the PICC compared to classical intravenous line in infants have required drug infusion and parenteral nutrition.^[8,9]

Today, due to specific or unknown causes, we are facing an increasing rate of high-risk pregnancies and, consequently, the birth of vulnerable neonates who need to be admitted to the NICU to receive specialized care. Research about identifying the side effects of using unavoidable equipment at the NICU will be directed to promoting the health of neonates. The present study assessed the complications of PICC in neonates admitted to the intensive care unit in hospital.

Materials and Methods

The present retrospective cohort study was carried out in the NICU of a tertiary referral center, Valiasr Hospital, Tehran, Iran, between 2015 and 2018. The sample size was determined by the formula of comparing the ratios between the two groups, 95% confidence percentage and 80% test power.

According to the local protocol, the PICC was implanted for the target group who were weighing less than 1,500 grams, required intravenous injections for a week or more, or needed Total Parenteral Nutrition (TPN). For such neonates, as soon as they were admitted to the NICU, first, an umbilical vein catheter was inserted and if they didn't develop complicated sepsis within 48 to 72 hours (according to the clinical symptoms and paraclinical tests such as complete blood count, c-reactive protein, and blood culture), the PICC was implanted. The PICC was inserted by a trained nurse and under the responsibility of a neonatal specialist. The PICC could also be implanted in neonates with septicemia after negative blood culture and normalization of tests. In exposure group, after setting the PICC up, an X-Ray was obtained to ensure that the PICC was inserted properly, and the PICC site was checked repeatedly for hemorrhage and inflammation. The PICC did not remain in place for more than 15 days and was removed as soon as necessary. The PICC was also removed in relation with obvious complication. All exposure neonates were under cardiopulmonary monitoring and parental consent was obtained for procedure of PICC insertion. During the same period, 1.50 times more than exposure group, which means 261 neonates of NICU that their hospitalization was not due to sepsis and had a negative initial blood culture, were included in the study, but 54 of them were excluded due to a defect in recording. In both study groups, information including of tachyarrhythmia, perforation of large veins, heart rupture, high pulmonary hypertension, cardiac tamponade, pericardial effusion, septicemia, hemorrhage, anemia, pleural effusion, ascites, phlebitis, and neonatal death were collected using the comprehensive neonatal registry of Valiasr Hospital. According to the protocol of this study, tachyarrhythmia was a condition in which the heart rate is more than 180 beats per minute for more than twenty minutes. Perforation of the large veins, heart

rupture, pulmonary hypertension, cardiac tamponade and also pericardial effusion should be confirmed by a pediatric cardiologist, in addition to the classic clinical signs. Local necrosis was defined as a cellular injury at least $5 \times 5 \text{ mm}^2$ at the site of cannula entry into the skin. The diagnosis of septicemia was made in neonates with clinical symptoms including general malaise, gray skin, mottling, scleroderma or respiratory distress, that also had positive laboratory results such as an increase in c-reactive protein, positive sterile body fluid culture, leukopenia, neutropenia or thrombocytopenia. Hemorrhage from the catheter site was considered significant if 10% or more of the neonate's circulatory volume (depending on the baby's weight) was lost. Anemia was referred to a hemoglobin $\leq 10 \text{ g/dL}$. Pleural effusion in our study included a decrease in pulmonary sounds on the affected side plus its proof in Chest-X-ray. The diagnosis of ascites was dependent to percuss a fluid wave in the abdomen examination to be approved by radiography. Phlebitis was also considered as redness, swelling and stiffness of the catheterized vein.

Finally, data were analyzed using the Statistical Package for the Social Sciences (IBM SPSS version 23) output of registry. The comparison of the means of gestational age and birth weight between the two groups was performed with independent *t*-test. A logistics regression test was used to examine true consequences of exposure and to eliminate the effect of intervening variables. Also, the mantel-haenszel test measured the relationship of local necrosis with septicemia cases in both groups. A *p* value < 0.05 was considered significant.

Ethical considerations

The subject of research and method of work was approved by the Medical Ethics Committee of Tehran University of Medical Sciences (Code number: IR.TUMS.IKHC.REC.1397.287). Parental consent had been obtained before catheterization.

Results

In this study, a comparison was made between 174 neonates in exposure group (with the PICC) and 207 neonates in control group (with IV-Line in peripheral veins). Gestational age in exposure group was less than controls [Mean (SD): 30.50 (3.22) vs Mean (SD): 31.50 (3.60) weeks, ($F = 7.48$, $p < 0.007$)]. Also, the birth weight in exposure group was Mean (SD): 1368.83 (667.18) grams compared to Mean (SD): 1757.30 (807.31) grams in control group ($F = 24.75$, $p < 0.001$). In this study, it was revealed that consequences such as hemorrhage in the catheter site, septicemia, and death in exposure group are significantly lower than in control group (p value < 0.05). Other complications such as pleural effusion, cardiac tamponade, pericardial effusion, ascites, and phlebitis were not recorded in the two exposure and control groups. Local necrosis was more frequent in exposure group according to Table 1, but this increase was not significant.

Anemia had a significant abundance in exposure group, but due to the possibility of interference of variables on each other, a double logistic regression test was used to evaluate the factors affecting the occurrence of consequences. This test, as shown in Table 2, found that septicemia and hemorrhage in the catheter site, independent from other variables, were inversely related to using the PICC and were less likely to occur if PICC was used, however death and local necrosis had no association with the catheterization type, and the both were related to other factors. In control group compared to exposure ones, the risk of septicemia and hemorrhage in injection site were 1.70 and 5.88 times higher, respectively. This study also assessed the relationship between septicemia and local necrosis in catheter site following extravasation. Table 3 demonstrates that the risk of septicemia in control group was significantly higher due to local necrosis at the catheter site ($p = 0.012$).

Discussion

In the present study, the incidence of some probable complications in 174 neonates with emplacement of the PICC and 207 neonates with classical peripheral venous catheters was compared. The gestational age and birth weight were higher in neonates with peripheral venous catheterization, according to the protocol of this unit to use the PICC in neonates with lower weight and lower gestational age, who are required extended hospitalization in the NICU and total parenteral nutrition. This policy is in line with international standards for the care of premature neonates in the NICU.^[1] The results demonstrated that septicemia and hemorrhage in the catheter site were significantly lower in exposure group, which means that using the PICC is a safe and

better method of care in vulnerable neonates with lower gestational age and birth weight. In our study, complications such as phlebitis, cardiac tamponade, pericardial and pleural effusion, and ascites were not observed. These results are compatible with findings of a study by Callejas *et al.*^[3] on the absence of pericardial effusion, ascites and cardiac tamponade, but in that study 5 cases of pleural effusion and 5 cases of phlebitis were reported out of a total of 689 PICC implants. Also, in a study by Wrightson, pericardial effusion and ascites were not observed, but 3 cases of pleural effusion and 4 cases of phlebitis were found from a total of 622 cases of the PICC.^[7] In a study by Ohki *et al.*^[5] from Japan, which collected data of 98 NICUs, between 0.10-0.14% of the PICC emplacement cases were associated with pleural effusion and ascites, but in only 0.10-0.11% of cases were reported pericardial effusion and cardiac tamponade. In another study of this researcher in 2013, 0.10% pleural effusion following the PICC placement in 19 NICUs was reported.^[10] A similar study in Turkey in 2010 by Bulbul *et al.*^[11] demonstrated that 5.20% of the PICC emplacement cases were associated with phlebitis, but pericardial and pleural effusion and cardiac tamponade were not reported. Finally, in a study by Gupta *et al.*,^[9] only pleural effusion was reported. These comparisons can lead us to this conclusion that pericardial effusion, ascites and cardiac tamponade are uncommon, but phlebitis and pleural effusion, although not seen in our study and some other researches, can be less common to occur. One reason we didn't find some side effects in our study may be that the number of neonates of exposure group was low. Of course, there is an interesting point, and that is the average birth weight of neonates with the PICC in our research (1368.83 (667.20) grams) was less than most of the studies mentioned before, except for Turkey and Japan,^[10,11] and so it was expected more complications to occur.

The occurrence of necrosis at the catheter site due to extravasation did not show a significant difference between the two groups in our study. Therefore, the incidence of necrosis may be more related to other variables such as gestational age, birth weight, diseases, and underlying conditions of neonates such as shock and asphyxia and even the brand of used catheters. Also, it is natural for most of the neonates in our case and control groups to develop necrosis, because they had less developed skin due to prematurity. Leakage or liquid extraction from PICC was reported to be 4.30% in Wrightson^[7] and about 0.7% in Kara,^[8] respectively, which is much lower than our study. However, the issue of extravasation in premature neonates is a well-known issue, and in some studies that have independently investigated its prevalence in NICUs; higher rates have been reported than in our study,^[12,13] although it is necessary to review in this area in independent research in the future.

In our study, it was found that the rate of septicemia in exposure group was significantly lower than control group and the logistic regression analysis demonstrated that in control group,

Table 1: The Comparison of complications between the two groups of control and exposure to PICC*

Consequence	Exposure group n (%)	Control group n (%)	p**
Catheter site necrosis	41 (24%)	39 (19%)	0.260
Injection site hemorrhage	5 (3%)	17 (8%)	0.026
Septicemia	42 (24%)	69 (33%)	0.049
Inappropriate cardiac function	4 (2%)	13 (6%)	0.061
Anemia	89 (51%)	81 (39%)	0.019
Death	22 (12.50%)	42 (20%)	0.047

*Peripherally Inserted Central Catheter, ** Chi-square test

Table 2: The possibility of related consequences with the emplacement of catheter in the control group compared to PICC*

Consequence	B	p**	OR***
Septicemia	0.56	0.025	1.74
Catheter site necrosis	-0.36	0.180	0.70
Injection site hemorrhage	0.77	0.002	5.88
Anemia	-0.20	0.378	0.81
Death	0.49	0.66	1.63

*Peripherally Inserted Central Catheter, ** Double logistic regression test, *** Odds ratio

Table 3: Investigation of the relationship of catheter site necrosis with septicemia cases in both groups

Groups		Septicemia	p^*	Common	Common
		n (%)		p	OR**
Case	Catheter site necrosis	13 (32%)	0.195	0.012	1.96
	Without Catheter site necrosis	29 (22%)			
Control	Catheter site necrosis	19 (48%)	0.024		
	Without Catheter site necrosis	50 (30%)			

* Mantel-Haenszel test, ** Odds Ratio

the occurrence of septicemia, independent from other variables, was higher and the possibility of its occurrence increased by 1.74 times. Moreover, the analysis of logistic regression demonstrated that the occurrence of septicemia following the necrosis at the catheter site was significantly higher in the control group, and in fact, this group was nearly 2 times more at risk of sepsis. Comparison of the occurrence of septicemia and infectious complications following PICC emplacement, in different studies with our study, shows that our results are in line with the results of previous studies. The rate of reported infectious complications associated with PICC emplacement in other studies was between 6.70% and 13%.^[3,4,7-11] In fact, this complication has been reported to be one of the most common complications that can be prevented entirely by following the principles of infection prevention and aseptic emplacement methods and proper maintenance.

We also had some limitations in this study. First, the research was conducted in only one center, which limited the number of cases we studied. At the same time, a significant number of parents were dissatisfied with the method due to its unfamiliarity and relative newness, which led to a small number of study cases. Because not all of the employees are equally proficient at using PICC, the effects will vary depending on the person who installed it and may justify the increase in some of the impact depending on the person who installed it. Although the two groups that we studied were not match and statistically had a higher gestational age and weight, we clearly showed that infectious and non-infectious complications were lower in the case group than the control group, and this is the strong point of our study. It is recommended that future studies should be conducted in larger sample sizes with different study settings or multicenter mode to compare the probable complications of emplacement of the PICC in Extremely Low Birth Weight (ELBW) and Very Low Birth Weight (VLBW) neonates, as well as its emplacement outcomes in upper and lower limbs of the body.

Conclusion

Using the PICC, especially in premature neonates, significantly reduced septicemia and hemorrhage in the catheter site compared to classical intravenous line. We suggest the PICC as a safe method in neonatal nursing care.

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Conflicts of interest

Nothing to declare.

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