Original Article

Complication and Dwell Time of Neonatal Peripheral Venous Catheters with and without Splint: A Descriptive, Correlational, and Prospective Study

Abstract

Background: The main challenge of using Peripheral Intravenous Catheters (PICs) for neonates is their short dwell time, which requires frequent catheterization. Interventions have been made to increase the length of time intravenous catheters stay in neonates, such as the use of splints. Therefore, this study was conducted with the aim of determining the complications and dwell time of PICs with and without splints in infants admitted to the neonatal intensive care unit. **Materials and Methods:** This descriptive, correlational, and prospective study included all eligible neonates based on the inclusion criteria in Mahdieh Hospital, Tehran (2024), who were divided into two groups with and without splints. The sampling method was census and for 3 months, the assessment of intravenous catheters of newborns was checked three times a day, and all related complications and dwell time catheterization using a researcher-made checklist. The data was analyzed using IBM SPSS 16 software. **Results:** Extravasation was the most common complication (52.40%) in the splint group, and obstruction was the most common (34.50%) in the non-splint group. The dwell time of peripheral venous catheterization mean, and standard deviation was 43.29 (33.12) hours in neonates with splints and 37.18 (7.70) hours in those without splints. The *t*-test demonstrated a significant positive impact of splints on catheter dwell time ($t_{375} = 2.59$, $p = 0.01$). **Conclusions:** There was a significant positive effect of splints on length of stay. However, splints may aid in the delayed detection of extravasation, whereas the absence of a splint may lead to an increased incidence of catheter occlusion, necessitating earlier catheter removal.

Keywords: *Complications, length of stay, newborn, splint, vascular access devices*

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Introduction

One of the most common nursing interventions in neonatal care is vascular access for administering fluids, nutrition, antibiotics, and other medications.[1] More than 80% of neonates undergo peripheral venous cannulation during hospitalization.[2] Establishing a safe, reliable, and enduring vascular access method is one of the most critical concerns for nurses in Neonatal Intensive Care Units (NICUs).[3] Complications of frequent catheter replacements include infection, tissue damage, limb deformity after prolonged immobilization, pressure damage to peripheral nerves, placement of an arterial catheter instead of a venous catheter, and pain from unsuccessful catheterization.[4] An important point in this regard is that successful catheterization is perceived when there are no local complications.[5] Generally, up to 75% of infants report a complication related to peripheral venous catheterization.[6] Many complications of venipuncture are somewhat preventable. Indeed, appropriate nursing care can reduce the incidence and severity of complications.[7] Furthermore, the most significant barrier to using peripheral venous catheters is their short dwell time, requiring repeated cannulation that leads to pathological stress for the infant, as cannulation is a painful procedure.[1] Owing to the increase in the risk of local infection and also venipuncture pain in these age groups, replacing peripheral venous catheters should not be done until complications arise, or intravenous treatment is completed.[8] In NICUs, the mean catheter dwell time is estimated to be between 23 and 40 hours.[9]

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In this regard, various methods are taken to increase the dwell time of venous catheters in neonates, such as using heparin locks, employing splints, and using infusion pumps. Splint is the dominant method used in most units.[2] Researchers have mentioned the advantages and disadvantages of using splints.[10] Commercially prepared splints can increase costs and can transmit infections from one infant to another.[11] The benefits of using splints include preventing unintended limb movements and tangling of internal venous catheters in neonates, and they can facilitate the free flow of intravenous fluids.[12] Additionally, splints may increase the duration of patency of peripheral venous catheters in neonates.[13]

Despite numerous studies recommending or not recommending the use of splints for peripheral intravenous accesses in neonates, contradictory results have been reported. A study conducted by Murali *et al*.[13] showed that the use of splints increases both the dwell time of the catheter and its patency. In a study conducted by Serane *et al*.,[1] in 2021, the mean catheter dwell time in preterm neonates was significantly less than in the group without splints. Another study in 2021 demonstrated a shorter functional lifespan of catheters in the splints group, although it was not statistically significant also the reasons for catheter removal were similar in both groups, and the researchers concluded that using splints did not prolong the dwell time of peripheral venous catheters in neonates.[11] Therefore, this study aimed to determine and compare the complications and dwell time of peripheral venous catheters with and without the use of splint in neonates.

Materials and Methods

This research is a descriptive, correlational, and prospective study. The research sample includes all infants admitted to the NICUs at Mahdieh, a maternal and neonatal hospital, in Tehran (2024). After obtaining written consent from the parents of the neonates and explaining the procedures followed were by the ethical standards of the responsible Committee on Human Experimentation and with the Helsinki Declaration in 2000. Sampling was conducted with the census method and neonates who met the inclusion criteria (admission to NICU and venipuncture with yellow (24) or purple (26) catheter, absence of specific diseases such as anemia and platelet reduction or platelet increase that increase the complications of PIC, absence of skin diseases that increase the complications of PIC, and catheterization in peripheral veins [not in the head veins]) were included in the study and this study continued for 3 months from September 2023 to December 2023. These infants required PIC, which was secured with or without splints based on the clinical judgment of the nurse. A total of 402 infants' data were recorded. Eleven neonates (4 discharged, 3 transferred to another unit, and 4 neonates because their postnatal age exceeded 28 days during the study period) were excluded and finally, the data of 391 neonates were analyzed. The data collection tool included a researcher-made checklist including three parts: (1) Demographic and clinical information of neonates. (2) Observational complications checklist at the time of catheter removal. (3) Demographic and clinical characteristics of nurses. To determine the validity of the observational checklist, the method of determining the content validity and face validity was used with the comments of six specialist nurses in the NICU and three nursing faculty members. To measure the reliability, two observers separately examined 15 neonates on one day, and intraclass correlation was calculated and the reliability of the instrument was determined.

In this study, all neonates requiring peripheral venous access with or without splints based on the nurse's judgment (the age and the size of the neonate, the number of other connections, the type of medications, and the duration of the need for a PIC) were included. From the time of insertion of the peripheral catheter with 24 (yellow) or 26 (purple) gauge, neonates were assessed three times a day (morning, evening, and night). The researcher's checklist was completed for each neonate, recording the catheter removal time and reason for removal. Before starting the sampling, the agreement coefficient between observers and research assistants was calculated. All individuals achieved an agreement score of over 80%. It is noteworthy that if an infant had more than one catheter, each catheter was considered a separate sample for monitoring. The obtained data were analyzed using the IBM SPSS16 statistical software.

Ethical considerations

This study was approved by the Research Ethics Committee of the School of Pharmacy and Nursing and Midwifery-Shahid Beheshti University of Medical Sciences with reference number IR.SBMU.PHARMACY.REC.1402.007. In this study, the procedures followed were in accordance with the ethical standards of the responsible Committee on Human Experimentation and

Table 1: Mean and standard deviation of quantitative demographic variables in infants (Mann–Whitney *U* test)

Variable	Group	Mean (SD)	Statistical test and *p*-value
Gestational age (weeks)	With splint	35.52 (2.74)	*u*=9923 0.001
	Without splint	33.21 (3.67)	
Birth weight (grams)	With splint	2295.02 (666.45)	*u*=9986; 0.001
	Without splint	1974.12 (798.71)	
Postnatal age (days)	With splint	6.99 (11.24)	*u*=9972.5; 0.001
	Without splint	10.51 (11.83)	
Neonatal weight at the time of catheterization (grams)	With splint	2577.03 (666.05)	*u*=9933.5; 0.001
	Without splint	1959.96 (809.38)	

with the Helsinki Declaration of 1975, as revised in 2000, and written consent was obtained from the parents of the infants participating in the study.

Results

Results showed variations in the frequency and percentage of neonatal variables in neonatal sex, injection or non-injection of blood products, type of injected blood product, and site of catheter placement; however, statistically, these differences were not significant [Tables 1 and 2]. Additionally, gestational age, birth weight, postnatal age, neonatal weight at the time of catheter placement, type of catheter, serum injection method, types of drugs or electrolytes with serum, injection of more than one intravenous solution, serum dextrose concentration, and significant statistical differences in two groups ($F_2 = 24.85$, $p < 0.001$) [Tables 1 and 2].

Moreover, the most common catheter-related complications in neonates with splints were extravasation (52.40%), and in those without splints, obstruction (34.50%). There was a significant difference in catheter-related complications between the two groups with and without splint use ($F_6 = 105.3$, $p < 0.001$) [Table 3]. The catheter dwell time in with splints group was (43.33 ± 29.12) more than without the splints group (37.70 ± 18.7) [Figure 1]. A comparison

Table 2: Number and percent of qualitative demographic variables in infants (Fisher's Exact test and Pearson Chi-Square test)

Variable		With splint	Without splint	Total	Statistical test and *p*-value
Sex*	Female	86 (46.50%)	112 (54.40%)	198 (50.60%)	x^2_1=2.42;0.12
	Male	99 (53.50%)	94 (45.60%)	193 (49.40%)	
Catheter size**	24	174 (65.10%)	166 (81%)	340 (86.60%)	x^2_1=17.74;0.001
	26	9 (4.90%)	39 (39%)	48 (12.40%)	
Infusion method***	Microset	184 (99.50%	173 (84%)	86 (46.50%)	F_2=24.85; 0.001
	Infusion pump + Microset	1 (0.05%)	28 (13.60%)	29 (74%)	
	Infusion pump	0 (0%)	5 (2.40%)	5 (13%)	
More than one infusion solution****	No	172 (93%)	156 (75.70%)	328 (89.90%)	x^2_1=21.44; 0.001
	Yes	13 (7%)	50 (24.30%)	63 (16.10%)	
Dextrose injection concentration*****	5%	53 (28.60%)	9 (4.40%)	62 (15.90%)	F_3=45.87; >0.001
	7.5%	0 (0%)	1 (0.05%)	1 (0.05%)	
	10%	132 (71.40%)	194 (94.20%)	326 (83.40%)	
	12.5%	30 (14.60%)	30 (14.60%)	30 (14.60%)	
Infusion of blood products $	No	180 (97.30%)	192 (93.05%)	372 (95.10%)	x^2_1=3.53;0.60
	Yes	5 (2.70%)	14 (6.80%)	19 (4.90%)	
Type of blood product	Packed cells	4 (2.20%)	8 (3.90%)	12 (3.10%)	F_3=1.90; 0.516
	FFP $$	1 (0.05%)	7 (3.40%)	8 (2%)	
	Platelets	0 (0%)	4 (1.90%)	4 (1%)	
	Cryoprecipitate	0 (0%)	0 (0%)	0 (0%)	
Intravenous access site $$$	Basilic vein	27 (14.60%)	50 (24.30%)	77 (19.70%)	F_6=14.87; 0.006
	Radial vein	87 (47%)	58 (28.20%)	145 (37.10%)	
	Axillary vein	8 (4.30%)	14 (6.80%)	22 (5.60%)	
	Saphenous vein	41 (22.20%)	57 (27.70%)	98 (25.10%)	
	Cephalic vein	12 (6.50%)	18 (8.70%)	30 (7.70%)	
	Femoral vein	7 (3.80%)	5 (2.40%)	12 (3.10%)	
	Popliteal vein	3 (1.60%)	4 (1.90%)	7 (1.80%)	
Nurses experience $$$$ (preparation IV $$$$$ line)	Less than 5 years	50 (27%)	28 (13.60%)	78 (19.90%)	x^2_4=30.44; >0.001
	5–10 years	19 (10.30%)	48 (23.30%)	67 (17.10%)	
	10–15 years	83 (44.90%)	66 (32%)	149 (38.10%)	
	15–20 years	27 (14.60%)	57 (27.70%)	84 (21.50%)	
	More than 20 years	6 (3.20%)	7 (3.40%)	13 (3.30%)	
Nurses experience (removal of IV line)	Less than 5 years	48 (25.90%)	24 (11.70%)	72 (18.40%)	x^2_4=16.41; 0.003
	5–10 years	24 (13%)	40 (19.40%)	64 (16.40%)	
	10–15 years	72 (38.90%)	96 (46.60%)	168 (43%)	
	15–20 years	30 (16.20%)	39 (18.90%)	69 (17.60%)	
	More than 20 years	11 (5.90%)	7 (3.40%)	18 (4.60%)	

*Pearson Chi-Square Test, **Pearson Chi-Square Test, ***Fisher's Exact Test,****Pearson Chi-Square Test, *****Fisher's Exact Test, $Pearson Chi-Square Test, $$ Fresh frozen plasma, $$$ Fisher's Exact Test, $$$$ Pearson Chi-Square Test, $$$$$ Intravenous

Table 3: Comparison of complications of peripheral vein catheter in two groups: With and without splint (Fisher's Exact test)

Complication	With splint	Without splint	Total	Statistical test and *p*-value
Bleeding	26 (14.10%)	14 (6.80%)	40 (10.20%)	F_6=105.3; >0.001
Extravasation	97 (52.40%)	55 (26.70%)	152 (38.90%)	
Edema	30 (16.20%)	44 (19.90%)	71 (18.20%)	
Obstruction and dysfunction	2 (1.10%)	71 (34.50%)	73 (18.70%)	
Unnecessary for a venous route	14 (7.60%)	0 (0%)	14 (3.60%)	
Accidental removal	6 (3.20%)	1 (0.50%)	7 (1.80%)	
Phlebitis	10 (5.40%)	24 (11.70%)	34 (8.70%)	

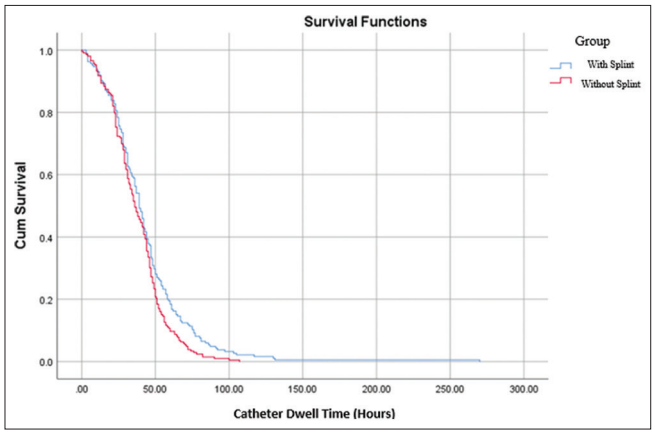

Figure 1: Comparison of catheter dwell time between the two groups: with and without splint

of catheter dwell time using a *t*-test showed a significant difference between the two groups ($F_6 = 14.87$, $p < 0.001$).

Discussion

A review of related studies about catheter complications in neonates indicates that limited research has been conducted on the association between peripheral intravenous catheter complications with and without the use of splints in neonates. Most studies related to this research have focused on the complications of peripheral intravenous catheters without considering the use or non-use of splints.

In line with identifying the most common complication associated with peripheral venous catheters and consistent with, Ju-Huei Tseng *et al.*, in Taiwan, reported extravasation as the most common complication of peripheral venous catheters in neonates, with an incidence of 55.9% in 2023.[14] Similarly, in a 2023 study by Nega Dagnew on complications related to peripheral venous catheters in infants in Ethiopia, the most common complication was infiltration, with an incidence of 42.1%. This study was conducted in the NICU and pediatric units, with infants aged 0 to 12 months.[9] Therefore, it can be concluded that extravasation is not only a common complication in the neonatal period but also likely remains prevalent in infants.

In this context, a study in Qatar found that extravasation was the most common complication, with an incidence of 42%.[6] The results of Nilesh Gourshettiwar *et al.*[15] study, in 2020 in India also showed that extravasation was the most common complication, with an incidence of 44% in the group of neonates with catheters size 22 and 59.80% in catheters size 24. In contrast, in this study, only size 24 (87.60%) and size 26 (12.40%) of venous catheters were used. Thus, it can be concluded that the complication of extravasation is not related to catheter size and can occur with all types of catheters. Additionally, in this study, the neonates were not randomly divided into two groups, as in clinical settings, the choice of catheter type or use of a splint is always based on the nurse's clinical judgment. In this regard, and consistent with the findings of this study, Serane *et al.*,[1] in 2022, randomly divided neonates into two groups: "with splint" and "without the splint." The results showed that the most common complication in both groups was extravasation, with an incidence of 84% in the splinted group and 76.50% in the without splints group.

Contrary to the findings of this study, the results of the study by Neha *et al.*[11] demonstrated that in both groups of neonates, with and without splints, the most common complication was extravasation (77.40%). The discrepancy between the results of that study and the present one lies in the similarity of the most frequent complication in both groups, regardless of splint use. Moreover, while this study is descriptive, the study by Neha *et al.* was conducted as a randomized controlled trial, and therefore, the smaller sample size may have influenced their results.

Additionally, Nikfarid *et al.*'s[16] study showed a significant relationship between the child's age and the use of total parenteral nutrition with the occurrence of catheter complications, and also phlebitis was the most commonly reported complication (74.60%) in the under-one-year age group. Notably, the study did not mention the use of splints, and the age group was infants under one year, which may explain the differing results due to these factors. Moreover, the lower rate of phlebitis in this study compared with Nikfarid *et al.*'s study could be attributed to the fact that in this study, the catheter was replaced upon the occurrence of infiltration, preventing the progression to phlebitis. Additionally, study methodologies, randomization, and sample size can all impact the study's outcomes.

In line with determining and comparing the dwell time of peripheral venous catheters, the results of this study showed that the catheter dwell time in the splint group was significantly longer. In the same context and consistent with the findings of this study, Murali *et al*.'s[13] study also demonstrated that neonates in the splint group had a longer dwell time of peripheral venous catheter. The researchers concluded that splints help maintain and keep peripheral venous catheters patent for a longer period compared with catheters without splints.

In this context, a study conducted in 2022 by Serane *et al*.[1] aimed to determine the impact of splints on the dwell time of peripheral venous catheters in neonates. This clinical trial revealed that the mean dwell time of intravascular catheter retention was significantly shorter in the splint group compared to the non-splint group. In a study, conducted in 2019 in Spain to identify the factors affecting the success of peripheral venous access in neonates, success was defined as the dwell time of the catheter and the absence of related complications. The mean and standard deviation dwell time of peripheral venous catheters in neonates was found to be 46.5 (33.90) hours in this study.[5] It is noteworthy that the catheter dwell time was longer than in this study. However, since splints were used for all neonates according to the hospital protocol, it can be concluded that splints may be a contributing factor to the prolonged catheter dwell time.

In contrast to the results of this study, the study by Kalantari *et al*.,[10] aimed to compare the effect of three supportive methods for peripheral venous catheter splints, transparent Angiocath tape, and 3M hypoallergenic tape on the dwell time of catheter, found no significant difference in the distribution of complications among the three groups. It is worth noting that this was a semi-experimental study with a sample size much smaller than that of this study. Additionally, a study conducted by Dalal *et al*.[17] in India, titled "Immobilization of the Limb in Neonatal Peripheral Venous Catheters," reported that the mean dwell time of cannula function in the splint group was shorter compared with the no-splint group, although this difference was not statistically significant. This result may be due to differences in birth weight between our study and theirs, as the birth weight of infants in our study was relatively higher. Moreover, the sample size in Dalal's study was very small, with only 69 peripheral venous catheters used.

Thus, a comparison of studies with findings consistent and inconsistent with this study indicates that multiple intervening variables likely affect the occurrence of complications and the dwell time of the catheter. Even the individual nurse may play a significant role in determining the catheter removal time. However, the combined use of evidence, study results, and the nurse's clinical judgment can lead to better catheter care, prevention of complications, and appropriate catheter dwell time. Additionally, it is important to note that a longer catheter dwell time does not necessarily equate to better catheter care.

One of the strengths of this study is the identification of factors that can increase the duration of PIC and reduce complications caused by it. Also, one of the limitations of the study is that sampling was conducted at a single center, and center policies such as disinfectant solution, catheter brand, and type of splint may have affected the study results, and the decision to use a splint was based on nurses' judgment.

Conclusion

The results of this study indicate that the use of splints has a significant positive effect on the dwell time of the catheter. Additionally, the findings suggest that splints may delay the detection of extravasation, while the absence of a splint may lead to a higher incidence of catheter obstruction, which in turn necessitates earlier catheter removal. Therefore, it appears that nurses should carefully consider the decision to use or not use a splint. In cases where prolonged catheter use is required, splints are recommended. However, other factors such as the appropriateness of the splint and careful monitoring of the vein and potential complications should also be meticulously considered.

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Conflicts of interest

Nothing to declare.

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