JERN Journal of Education and Research in Nursing

Original Article
DOI: 10.5152/jern.2021.80488

Peripheral Venous Catheterization Success and Affecting Factors in Newborns

Halil İbrahim Taşdemir
Emine Efe

Akdeniz Üniversitesi, Hemşirelik Fakültesi, Çocuk Sağlığı ve Hastalıkları Hemşireliği Anabilim Dalı, Antalya, Türkiye

ABSTRACT

Background: The application of peripheral venous catheters in neonatal units is a widely utilized technique including risks in newborns. The aim of this study is to determine the incidence, risk factors, and complications of peripheral venous catheterization attempts in newborns.

Methods: This descriptive study, treatment and care of a university hospital neonatal intensive care unit in the 87 neonatal peripheral venous catheters 406 applications were observed in Turkey. The research was applied between July-October 2019. The variables of the study were gender, age, week of gestation, catheterization site, and type of catheter, insertion attempt number, catheter length of stay, and complication.

Results: 406 catheters were monitored for 36.5 ± 13.8 hours and 118 of 246 catheters were removed after the completion of the treatment (Success 47.97%). The most preferential regions were the dorsal region (58.13%) and the cubital fossa (14.22%) and the dorsal area of the feet (15.04%). The most common complications were found to be infiltration/extravasation (35.77%) and phlebitis (8.94%).

Conclusion: The preferential application locations are the dorsal hand and the cubital fossa, with less complication, longer catheterization, and less procedure for catheterization. The dorsal region on hand is recommended as the first choice in terms of fewer trials for cannulation.

Keywords: Newborn, catheterization, venous catheter, neonatal intensive care

Introduction

Peripheral intravenous catheters (PIVC) are commonly used in all healthcare facilities.[1] The guidelines recommend umbilical venous catheters (UVC) for administering the necessary drugs during neonatal resuscitation.[2] It can be difficult in the long term in newborns who require a UVC Ventilator and/or cardio-circulatory support. The frequently preferred option is a peripheral intravenous catheter. PIVC is also widely used in the treatment of intravenous high-risk infants. Though PIVC can cause some health problems in this population, nurses can prevent complications from catheterization and/or care.[2]

The practice is carried out by the nurses managing for application, care and elimination of the catheter.[3] Peripheral venous catheterization in newborns has a number of risks. In order to minimize these risks, the catheterization procedure requires appropriate care as well as technique, knowledge, competence, skill. Even an experienced nurse can take multiple attempts to insert a PIVC. This average is reported as 1.4 attempts.[4]

Frequent complications are noticeable. Local complications should be observed around the catheter site. These complications; Common complications are noticeable. Local complications should be observed around the catheter site. These complications; It is categorized as thrombosis, infiltration, hematoma, phlebitis, extravasation, thrombophlebitis and local infection.[5,6] Complications should be detected early in order to minimize the damage that may occur. Therefore, the peripheral venous catheter status should be constantly monitored.[7]

Keeping the peripheral catheter closed may reduce the living of the PIVC and reason blockage because of clotting of the catheter tip. No studies were found to define whether the care of the peripheral tract beggars constant liquid treatment.[1,8] The time and lifetime of PIVCs in newborns depend on vein fragility. It is reported between 35 hours and 96 hours on average.[9,10] It is recommended to use the most appropriate catheter to minimize the damage to the peripheral vascular system, to increase success and to facilitate hemodilution.[7]

Taşdemir Hİ, Efe E. Factors Affecting Peripheral Venous Catheterization Success in Infants: A Descriptive Study. *J Educ Res Nurs*. 2021;18(2):174-179.

Corresponding Author: Emine Efe
E-mail: eefe@akdeniz.edu.tr

Received: November 20, 2019
Accepted: April 12, 2020

Protection of the PIVC is also very important. Dress wound and unnecessary catheter changes should be avoided. However, the insertion area should be left visible in order to hinder the penetration of fluids and microorganisms from the outside to the derm. Today, semi-conductive clear dressing has become the more widely applied instrument.[11]

Considering its characteristics such as maintaining peripheral venous catheterization success in high-risk newborns, vascular fragility, and physiological and clinical instability in this population, the PIVC procedure appears to be a challenge for nurses. One of the most painful and stressful procedures encountered by risky newborns is the PIVC procedure. In case of failure of PIVC, possible complications may lead to the prolonged hospital stay and the development of additional complications and neurodevelopmental disorders in the next period. It is very important for newborn health to determine the success status and related factors of such an important application.

Aim

The main aim of this study is to define the incidence and types of complications of PIVC, to define the important risk factors for PIVC failure, and to determine success defined as the absence of associated complications.

Methods

This is a descriptive study. The universe of the study was the newborns in the Neonatal Intensive Care Unit (NICU) of the Akdeniz University Hospital. Infants are admitted to the first, second or third level NICU with technological equipment, depending on their clinical condition. An average of 260 newborns receives care and treatment per year in this unit. Newborns aged 0-28/day who underwent PIVC intervention in the NICU and whose parental consent was obtained were included in the sample. All newborns who received care and treatment in the NICU between July and October 2019 and who met the criteria were included in the study. Sample size calculation was not done. The sample included 87 neonates who underwent 406 peripheral intravenous catheters, corresponding to an average of 4.67 catheters per newborn. Nine newborns that were not given permission to participate in the study by their parents were excluded from the study. PIVC application and care were performed by trained NICU nurses.

Newborn Identification Form and Newborn PIVC Status Registration Form created by the researchers were used to collect data in the study. In these forms, there are records such as the newborn's age, weight, catheter placement, catheter location, duration of use, number of attempts, treatment manipulation and removal, and possible complications related to the catheter. Data were obtained by a researcher every day, in the afternoon, from information contained in the neonates' medical records and by direct observation of the catheterization process. For this reason, each newborn included in the study was followed up for PIVC during the hospital stay and the changes were recorded daily.

Written informed consent was obtained from the parents of the newborns included in the study. In addition, permission was obtained for the implementation of the study with the decision numbered 974, dated June 2019, from the Akdeniz University Clinical Research Ethics Committee.

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS) for Windows, Version 25.0. (IBM Corp.; Armonk, NY, USA) was used to analyze the data.[12] Quantitative variables were defined using mean and standard deviation. Kolmogorov–Smirnov test was used to test the normality distribution with analytical tests. However, Field[13] stated that since Kolmogorov-Smirnov and Shapiro-Wilk tests can be conservative, they will give more reliable results with skewness and kurtosis coefficients in determining normality. Therefore, the skewness and kurtosis coefficients were also used in the normality test. When the Kurtosis and Skewness values were between -1.5 and +1.5, it was accepted that there was a normal distribution.[13] In testing the normality distribution in our study, our results for all variables were found to be between -1.5 and +1.5, so parametric tests were applied. In the bivariate analysis, One-way analysis of variance (ANOVA) and chi-square test for categorical data was applied for success/failure variants. Binary logistic regression analysis of success/failure was carried out to remove potential disarranging variables. The significance level was accepted as $P < .05$.

Results

It was determined that 406 PIVC was applied in 87 newborns in total, and the reason for removal was not recorded in the nurse observation form in 160 (39.40%) of them. Complications did not develop in 118 (47.96%) of 246 catheter applications, for which information about the entire termination process of peripheral intravenous catheterization (PIVC) applied to newborns was found. On the other hand, 110 catheters (44.07%) were removed voluntarily (treatment, discharge and completion of post-mortem procedure). It was found that 8 catheters (7.31%) were removed by accident (Figure 1).

In the study, the incidence of catheter complications was found to be 52.04% (n=128). Of these, 22 (17.18%) were phlebitis, 88 (68.77%) were infiltration/extravasation, and 18 (14.06%) were obstruction (Figure 1). Infiltration and extravasation complications were classified in one group. Because the neonatal nurse could not be categorized differently since they did not record these two conditions differently during registration. Complications were found in 19.54% (n=28) of the first successful catheter applied to newborns. Although obstruction and infiltration/extravasation were more common on the first catheterization of the newborn, it was found that the rate of phlebitis reached the highest level in the fourth catheter placed in the same newborn. The attempts number voiced as the ease of applying of the IV cannula was found to be the dorsal part of the hand as the most easily cannulated area 63.8% (n=286). It has been determined that the success in this entrance region is 35.5% higher than the total average. Alternatively, the scalp has been found to be the most difficult area, with more attempts to achieve insertion. It was determined that 34.2% of newborns had at least three trials. When the remaining regions were examined, it was put forward that accomplished catheterization was got in 38.9% (n=61) in the first trial in the forearm, 34.8% in the cubital area (n=64), and 20.3% in the leg (n=23.9%).

It has been found that complications due to catheterization usage are free of the catheterization area. The areas with the most complication was the up extremities, but mostly the left (n=28; 21.88%) and right (n=24; 17.75%) upper extremities, after by the left lower extremity (n=15; 11.71%) and were head (n=8, 6.25%). It was found that the insertion site of the catheter significantly affected catheter duration ($P < .05$). It was found that the longest time was in the cubital site (49.9 ± 33.4 hours) and in the dorsal hand (48.9 ± 34.6 hours).

The most frequently selected catheter size was found to be 26G in 82.26% (n=312) of the newborns. The preferential applying area for both catheter types was found to be statistically significantly different ($P < .05$). This difference was found to be the dorsal part of the hand for the 26G catheter. It was found that catheter time was not statisti-

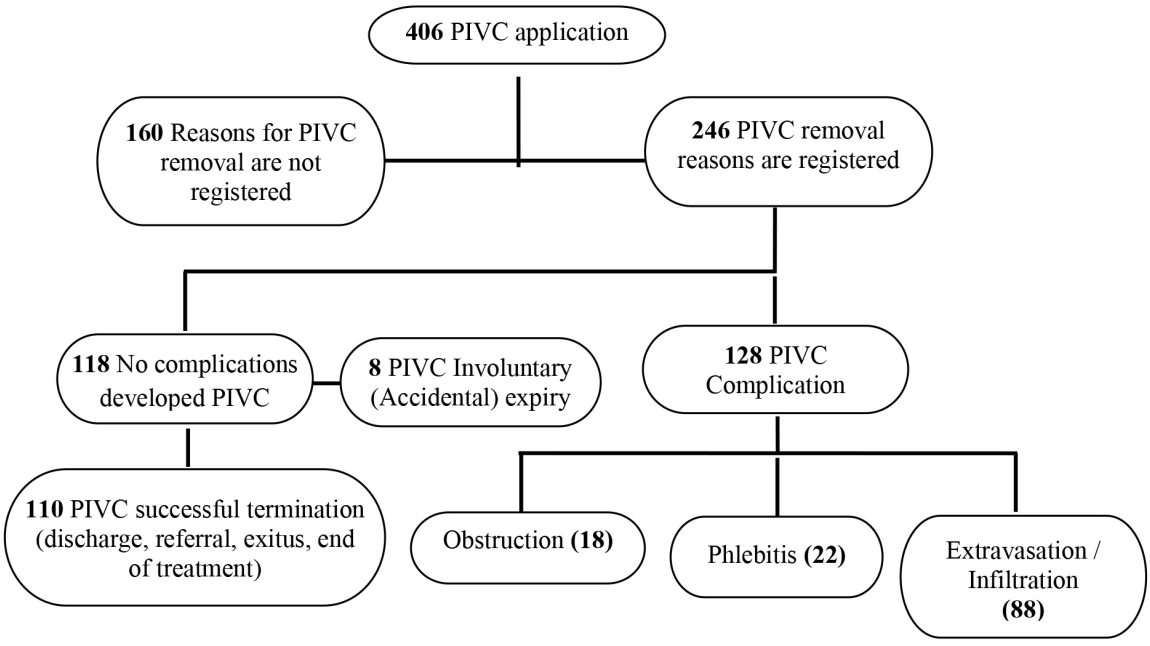

Figure 1. Process distribution of complications from peripheral intravenous catheter (PIVC) application of newborns

cally affected by type applied, only lightly long time for 24 G catheters (52.7 h; *P* > .05) (Table 1).

Success in the technic defined as cannula elimination after finishing treatment was found to be 44.07% (n=110). The achievement was high in cannulas accommodated in the cubital site (40%; n=44) and hand site (45.5%; n=50). The mean duration of all catheters was 36.5 ± 13.8 hours, for cannulas classified as accomplished; this rate was determined to be 28.8% (59.9 ± 37.7 hours) (Table 1).

Research of risk factors related to complications in peripheral intravenous catheterization usage was performed by categorizing and comparison cannulas with the existence or lack of complications. It was found that the possibility of developing complications in infants with an infection at the time of catheterization was 1.25 times higher (*P* < .05; RR=1.24). It was found that the decrease in the birth weight of the infant was significantly associated with the PIVC complication (*P* < .05, RR=1.3). It was found that the type of discontinuous infusion reduced the risk of growing complications, whereas the risk of developing PIVC complications was higher in newborns receiving continuous infusion (*P* < .05: RR=.70 and RR=1.19, respectively). It was found that the probability of developing complications associated with PIVC application in newborns who underwent endotracheal intubation was 1.32 times higher (*P* < .05; RR=1.37) (Table 1). It was found that total parenteral nutrition (TPN) administration via a peripheral catheter increased the risk of developing complications 1.62 times (*P* < .05, RR=1.29 and RR=1.59, separately). The usage of the IV route used for other infusions for blood transfusion increased the risk by 1.24 times, while the specific use of the catheter for blood transfusion alone reduced the risk by .37 times (*P* < .05; RR=1.24 and RR=.37, respectively). It was found that the risk of growing complication were higher in the first four days after catheterization (*P* < .05). Potentially serious complications did not develop and all cases were identified at the initial stage (Table 2).

Discussion

Complications developed in more than half of the cases in a study conducted to determine the frequency of peripheral venous catheterization, the development of complications and the affecting factors in neonatal intensive care units. This result is within the limits defined in studies with similar populations. Complications were found in 52.04% of the participants. In spite of the high rate, the rate found is within the borders described in researches with parallel populations. Studies show that the complication rate varies between 55.3% and 83%.[1,14,15] In terms of complications identified in this study, infiltration/extravasation was the leading rate with a rate of 68.77%. Then phlebitis (17.18%) and obstruction (14.06%) were the most common complications. Similarly, while infiltration (20-56%) and extravasation (24-48.3%) were defined as the most common complications in the literature, it was observed that the results of the research were generally in line with the literature.[1,8,14,15] The rate of infiltration/extravasation observed in this study (69.89%), as seen in Table 2, was found to be higher than the literature. However, infiltration/extravasation observed in this study (Table 1) was found to be higher than in other studies. This result suggested that nurses' co-occurrence of infiltration and extravasation had an effect.

The physiology of infants is defined look like a preliminary factor in the development of infiltration and extravasation due to the delicate structure of capillary vessels. Some researchers underline that newborns carry a special risk for the development of infiltration/extravasation. Since hypodermic tissues are elastic and readily stretched in the existence of fluid. In addition, impairment of venose totality eases capillary leakage.[16] It may be straightly associated with the profile

Table 1. Comparison of Catheter Entry Sites According to Demographic Characteristics of Newborns and PIVC Variables

Variables	Total n=87 (406 PIVC) Mean ± SD	Dorsal hand n=286 Mean ± SD	Forearm n=61 Mean ± SD	Cubital fossa n=65 Mean ± SD	Foot n=38 Mean ± SD	Scalp n=19 Mean ± SD	Test	*P*
Weight (g)	3021 ± 709	2993 ± 692	2988 ± 716	2996 ± 707	3187 ± 743	3163 ± 741	3.713a	.083
Gestation Age	38.2 ± 3.4	38.1 ± 4.3	38.6 ± 5.1	38.3 ± 4.4	38.0 ± 2.7	38.4 ± 3.8	2.859a	.343
Duration (h)	36.5 ± 13.8	49.8 ± 34.6	31.2 ± 29.4	50.3 ± 33.4	30.1 ± 27.4	35.7 ± 32.7	3.890a	<.001
Catheter type	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)		
26G	312 (82.26)	240 (84.0)	48 (78.7)	52 (80.0)	30 (79.0)	15 (79.0)	8.942b	<.001
24G	63 (12.2)	40 (14.0)	9 (14.7)	10 (15.4)	6 (15.8)	4 (21.0)		
Other	31 (6.0)	6 (2.1)	4 (6.6)	3 (4.6)	2 (5.2)	0		
Number of Attempts								
1	190 (46.8)	180 (63.7)	24 (39.4)	22 (33.9)	8 (21.1)	2 (10.6)	8.614b	<.001
2	100 (24.6)	65 (22.7)	17 (27.9)	20 (30.8)	12 (31.6)	1 (5.3)		
≥3	116 (28.6)	41 (13.6)	20 (32.7)	23 (35.3)	18 (47.3)	16 (84.1)		
Continuous infusion	159 (64.6)	39 (24.5)	35 (22.1)	29 (18.2)	31 (19.5)	25 (15.7)	6.563b	.064
Reason for Removal:								
Obstruction	18 (7.32)	3 (1.22)	4 (1.63)	3 (1.22)	5 (2.03)	3 (1.22)	7.145b	.017*
Extravasation /	88 (35.77)	20 (8.13)	18 (7.32)	22 (8.94)	24 (9.76)	4 (1.63)		
Infiltration	22 (8.94)	7 (2.85)	7 (2.85)	5 (2.03)	3 (1.22)	0		
Phlebitis	118 (47.97)	38 (15.44)	24 (9.76)	30 (12.19)	20 (8.13)	6 (2.43)		

[a]: one-way ANOVA, [b]: (χ^2) Chi-Square
* $P < .05$
**Complications of infiltration and extravasation are given in a single group in the records kept by NICU nurses.

of the newborn hospitalized in the ICU. Because these newborns are unstable and require intensive care due to preterm birth, low birth weight, and low Apgar scores.[17] Therefore, the best way to protect complications is the constant watch of the cannula insertion area and instant intervention on the emergence of these situations. Research conducted shows that two-thirds of NICUs usage protocols prevent these situations by taking evaluates such as continuous observation of the device application area, the ostium of the cannula to remain observable, and liquid infusion.[18]

When it comes to fluids that are infused into the cannula, the literature underlines 4 features that enable the risk of extravasation; osmolarity, excessive pH, cytotoxicity, and vasoactivity. Since this study is a study on newborns, considering these risk factors, the presence of vascular structures prone to extravasation can also be considered as a facilitating factor. Regardless of the infusion liquid, its properties vary with the concentration of the drug and diluent used in the preparation of the intravenous mixture. It may cause cell injury or death of the vascular cells. Using other liquids, even if isotonic, may cause critical damage to newborns.[19] In the event of infiltration/extravasation, elimination of the cannula is the common behavior, next by elevation of the extremity and the use of compresses.[18] When the happening of a bad situation, the extent of infiltration relative to the affected site should be assessed using certain applications, which is an important intervention to prevent harm to infants.[18] In our study, approaches like those in the literature were applied by the NICU staff to newborns who developed PIVC complications.

Phlebitis rates (17.18%) were found to be high in this study than other researchers (3.5-14%).[1,14,15] According to the literature, admissible phlebitis rates are lesser than 5%.[19,20] The reason for this high result in our study is thought to be due to the fact that premature newborns increased this percentage of phlebitis. Phlebitis protection applications include the application of hand hygiene procedures. Using a traditional technique, washing the hand with soap and water for the recommended times or rubbing the hand with 70% alcohol is sufficient for hand hygiene. In addition, when the neonatal catheter site shows signs of infection, the catheter should be removed without delay.[7] The neonatal team aiming to minimize the complications related to the use of PIVC should pay attention to early diagnosis and routinely evaluate the continuous catheterization site for signs of infection and other complications. These acts may reduce the pain and injury of infants in complications from peripheric IV treatment. In our study, the presence of infection in the newborn on the day of catheterization (whether or not connected to the catheter) was statistically significant for the development of complication ($P < .05$). Namely, when infants have a systemic infection such as sepsis, complications probably develop in the cannula. A systematic review examining studies in the neonatal population between 2000 and 2011 showed that PIVC is associated with infection rates in newborns.[24]

The low weight of the newborns (LBW) significantly increased the risk of complications during catheter use ($P < .05$). Because the vascular structures of preterm newborns are thinner and not fully developed, prematurity or LBW, including adverse events that may occur, define

Table 2. Bivariate Analysis and Intravenous Catheter Success

Variables	Total (n=87) (406 PIVCs) Mean±SD	Dorsal hand (n=286) Mean±SD	Forearm (n=61) Mean±SD	Cubital fossa (n=65) Mean±SD	Foot (n=38) Mean±SD	Scalp (n=19) Mean±SD	*P*
Weight (g)	3021 ± 709	2993 ± 692	2988 ± 716	2996 ± 707	3187 ± 743	3163 ± 741	0.083
Gestation age	38.2 ± 3.4	38.1 ± 4.3	38.6 ± 5.1	38.3 ± 4.4	38.0 ± 2.7	38.4 ± 3.8	0.343
Duration (h)	36.5 ± 13.8	49.8 ± 34.6	31.2 ± 29.4	50.3 ± 33.4	30.1 ± 27.4	35.7 ± 32.7	<0.001
Catheter type	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	
26G	312 (82.26)	240 (84.0)	48 (78.7)	52 (80.0)	30 (79.0)	15 (79.0)	<0.001
24G	63 (12.2)	40 (14.0)	9 (14.7)	10 (15.4)	6 (15.8)	4 (21.0)	
Other	31 (6.0)	6 (2.1)	4 (6.6)	3 (4.6)	2 (5.2)	0	
Number of attempts							
1	190 (46.8)	180 (63.7)	24 (39.4)	22 (33.9)	8 (21.1)	2 (10.6)	<0.001
2	100 (24.6)	65 (22.7)	17 (27.9)	20 (30.8)	12 (31.6)	1 (5.3)	
≥3	116 (28.6)	41 (13.6)	20 (32.7)	23 (35.3)	18 (47.3)	16 (84.1)	
Continuous infusion	159 (64.6)	39 (24.5)	35 (22.1)	29 (18.2)	31 (19.5)	25 (15.7)	0.064
Variables	**Total (246 PIVCs) n (%)**	**Dorsal hand n (%)**	**Forearm n (%)**	**Cubital fossa n (%)**	**Foot n (%)**	**Scalp n (%)**	***P***
Reason for removal							
Obstruction	18 (7.32)	3 (1.22)	4 (1.63)	3 (1.22)	5 (2.03)	3 (1.22)	0.017*
Extravasation/infiltration	88 (35.77)	20 (8.13)	18 (7.32)	22 (8.94)	24 (9.76)	4 (1.63)	
Phlebitis	22 (8.94)	7 (2.85)	7 (2.85)	5 (2.03)	3 (1.22)	0	
End of treatment	118 (47.97)	38 (15.44)	24 (9.76)	30 (12.19)	20 (8.13)	6 (2.43)	

[a]*P* < .05. PIVC, peripheral intravenous catheter; SD, standard deviation.

a risk factor.[25] Regarding the kind of infusion for IV treatment, discontinuous infusions are most suitable for infants as it reduces the risk of emerging complication with peripheral intravenous catheterization. On the other hand, constant infusion application raises the risk of complications in the cannula (*P* < .05).

Total Parenteral Nutrition (TPN), blood transfusion, and infusion of drugs were found to be riskier in terms of complications. In TPN administration (*P* < .05), solution concentration, in addition to continuous infusion, is thought to be a risk factor that can damage the delicate venous network of neonates. It was determined that TPN application and hospital stay duration was longer in children who developed sepsis due to TPN treatment in Chile (*P* < .05).[26] In the study, it was reported that antibiotics and Total Parenteral Nutrition increased the risk of extravasation in children when performed with peripheral intravenous catheterization.[19]

Our study findings showed that the risk of developing complications is higher in the first two days after catheterization (*P* < .05). This situation reveals the importance of catheter care and follow-up within the first 48 hours after catheterization. At the same time, in this study, it was determined that the treatments initiated after the catheterization procedure had hemodynamic instability in the newborn and occurred especially in the first two days of life.

Limitations

Since the infiltration and extravasation status is not recorded separately in the patient files in the NICU, these two different complications could not be categorized. Therefore, infiltration and extravasation complications were defined in one group.

Conclusion

In this study, the prevalence of PIVC-related complications in newborns hospitalized in the NICU is 63.15%. It is observed that 34.2% of the newborns achieved success after at least the third attempt. Infiltration/extravasation, phlebitis and occlusion were determined to be the most common complications in PIVC applications. In this study, risk factors for complications associated with the usage of cannulas can be counted as the day of catheterization, existing infection in the newborn and weight of the newborn, type of infusion, PIVC insertion site, and TPN application. The risk of developing complications is even greater within the first two days after catheterization. Discontinuous infusion is the first-choice type for cannula care. TPN application is not suggested for this type of catheterization. However, regardless of the type of infusion used, it is suggested to usage an aseptic way maintain the catheter. The reasons for cannula removal and the lack of information to define the level of complications reveal the importance of regular and detailed records both for the benefit of the newborn

and for obtaining healthier results in possible studies. Similar studies are suggested to be developed to talk about infiltration, phlebitis, and degrees of extravasation, and the correct difference of the second complication.

Ethics Committee Approval: Ethics committee approval was received for this study from the Akdeniz University Clinical Research Ethics Committee (974-2019).

Informed Consent: Obtained from the parents of the newborns who participated in the study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – H.İ.T.; Design – H.İ.T., E.E.; Supervision – E.E.; Resources – H.İ.T.; Materials – H.İ.T., E.E.; Data Collection and/or Processing – H.İ.T.; Analysis and/or Interpretation – H.İ.T., E.E.; Literature Search – H.İ.T.; Writing Manuscript – H.İ.T.; Critical Review – E.E.

Acknowledgements: We would like to thank the Akdeniz University Neonatal Intensive Care Unit staff, the valuable newborns and their valuable families for their contribution to the study.

Conflict of Interest: The authors have no conflict of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

References

1. Perez A, Feuz I, Brotschi B, Bernet V. Intermittent flushing improves cannula patency compared to continuous infusion for peripherally inserted venous catheters in newborns: results from a prospective observational study. *J Perinat Med.* 2012;40(3):311-314.
2. Johann DA, Lazzari LSM, Pedrolo E, Mingorance P, Almeida TQR, Danski MTR. Peripherally inserted central catheter care in neonates: an integrative literature review. *Rev Esc Enferm USP.* 2012;46(6):1503-1511. [Crossref]
3. International Council of Nurses - ICN (2012). ICN code of ethics for the nursing profession. Switzerland. http://www.enfermerialeon.com/docs/comision_deo/CodigoCIE2012.pdf/
4. Gomes ACR, Silva CAG, da Gamarra CJ, Faria JCO, Avelar AFM, Rodrigues EC. Assessment of phlebitis, infiltration and extravasation events in neonates submitted to intravenous therapy. *Escola Anna Nery.* 2011;15(3):472-479. [Crossref]
5. Barria M, Santander G. Peripheral vascular access in newborn of intensive care unit: experience of a public hospital. *Ciencia y Enfermería.* 2006;12(2):35-44. [Crossref]
6. Nercelles P, Vernal S, Brenner P, Rivero P. Risk of bacteremia associated with intravascular devices stratified by birth weight in born of a public hospital of highcomplexity: Follow-up to seven years. *Revista Chilena de Infectología*. 2015;32(3):278-282. [Crossref]
7. O'Grady NP, Alexander M, Burns LA, et al. The healthcare infection control practices advisory committee (HICPAC) (ap-pendix 1). *Clin Infect Dis.* 2011;52(9):e162-193.
8. Arnts IJ, Heijnen JA, Wilbers HT, van der Wilt GJ, Groenewoud JM, Liem KD. Effectiveness of heparin solution versus normal saline in maintaining patency of intravenous locks in neonates: a double blind randomized controlled study. *J Adv Nurs.* 2011;67(12):2677-2685. [Crossref]
9. Jiménez-Pérez JM, Rodríguez-Rodríguez L, García-Villanueva S, Revilla-Llarena, M. Utilización y mantenimiento de los catéteres periféricos en la unidad deneonatología del Hospital Universitario Río Hortega, Valladolid. *Revista Enfermería CyL.* 2015;7:3-11.
10. Unbeck M, Förberg U, Ygge BM, Ehrenberg A, Petzold M, Johansson E. Peripheral venous catheter related complications are common among paediatric andneonatal patients. *Acta Paediatrica.* 2015;104:566-574. [Crossref]
11. Corredor-Cazcarro R, Barba-Flores MA, Martínez-Muñoz M, Zuriguel-Pérez E, Martínez-Ramos P, García-Alarcón X. Protective heel pads in pressure ulcer prevention. *Revista ROL de Enfermería.* 2018;4:141-146.
12. IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.
13. Field A. Discovering statistics using spss. 3rd ed. London: SAGE Publications; 2009.
14. Perez JMJ, Villanueva SG, Rodríguez LR, Llarena RMR. Utılızacıón And Maintenance of Peripheral Venous Catheters in the Neonatal Unit of the Unıversıtarıo Río Hortega Hospital, Valladolıd. *Revista Enfermería CyL.* 2015;7(1):3-11.
15. Barbosa MTDSR, Alves VH, Rodrigues DP, Branco MBLR, de Souza RDMP, Bonazzi VCAM. Quality indicators in support of intravenous therapy in a university hospital: a contribution of nursing. *Rev Pesqui Cuid Fundam.* 2015;7(2):2277-2286. [Crossref]
16. Hetzler R, Wilson M, Hill EK, Hollenback C. Securing pediatric peripheral IV catheters–application of an evidence-based practice model. *J Pediatr Nurs.* 2011;26(2):143-148. [Crossref]
17. Wu J, Mu D. Vascular catheter-related complications in newborns. *J Paediatr Child Health.* 2012;48(2):E91-95. [Crossref]
18. Lages CDR, de Sousa JCO, Cunha KJB, da Costa N, dos Santos TMMG. Predictive factors for the admission of a newborn in an intensive care unit. *Revista da Rede de Enfermagem do Nordeste*. 2014;15(1):3-11. [Crossref]
19. Restieaux M, Maw A, Broadbent R, Jackson P, Barker D, Wheeler B. Neonatal extravasation injury: prevention and management in Australia and New Zealand-a survey of current practice. *BMC Pediatrics.* 2013;13(1):34. [Crossref]
20. Simona R. A pediatric peripheral intravenous infiltration assessment tool. *J Infus Nurs.* 2012;35(4):243-248. [Crossref]
21. Clark E, Giambra BK, Hingl J, Doellman D, Tofani B, Johnson N. Reducing risk of harm from extravasation: a 3-tiered evidence-based list of pediatric peripheral intravenous infusates. *J Infus Nurs.* 2013;36(1):37-45. [Crossref]
22. Intravenous Nursing New Zealand Incorporated Society. Provisional infusion therapy standards of practice. New Zealand. 2012.
23. Gorski LA, Hallock D, Kuehn SC, Morris P, Russell JM, Skala LC. Recommendations for frequency of assessment of the short peripheral catheter site. *J Infus Nurs.* 2012;35(5):290-292. [Crossref]
24. Hadaway L. Short peripheral intravenous catheters and infections. *J Infus Nurs.* 2012;35(4):230-240. [Crossref]
25. Lanzillotti LDS, Seta MHD, Andrade CLTD, Mendes Junior WV. Adverse events and other incidents in neonatal intensive care units. *Cien Saude Colet.* 2015;20:937-46. [Crossref]
26. Balboa Cardemil P, Castillo Durán C. Risk factors of bloodstream infections associated with parenteral nutrition in pediatric patients. *Nutr Hosp.* 2011;26(6):1428-1434.