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Factors Influencing the Success of Peripheral Venous Access in Neonates

David Monasor-Ortolá, RN [a,b], Ernesto Cortés-Castell, PhD [c,*], Carla Martínez-Pascual, RN [a], Antonio Esteve-Ríos, RN [a], María Mercedes Rizo-Baeza, RN, PhD [b]

[a] Vinalopó University Hospital (Elche), Spain
[b] Nursing Department, University of Alicante, Spain
[c] Department of Pharmacology, Pediatric and Organic Chemistry, University of Miguel Hernández, Spain

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ABSTRACT

Purpose: In neonatal units, the use of peripheral venous catheters is a commonly used technique involving risks and local complications. Catheter duration and viability is limited and may involve multiple insertion attempts. Catheterization was considered successful when there were no local complications and the catheter was removed owing to completion of treatment. The aim of the study was to determine the optimal location and instruments to reduce the number of catheter insertion attempts and to increase time without complications.

Design and methods: A cross-sectional descriptive study was undertaken to analyze all the catheters inserted in the neonatal intermediate care unit of Vinalopó University Hospital (Elche, Spain). Between 2013 and 2017 the following variables were collected: sex, age, gestational age, and venipuncture site, as well as catheter type, number of insertion attempts, duration and complications.

Results: A total of 929 catheters were analyzed with a mean duration of 46.5 ± 33.9 h, and were removed upon completion of treatment (success 38.3%). The preferred site was the dorsal hand (48.2%) followed by the cubital fossa (20.1%). In both sites the success of the catheter and its duration was higher than the mean (42.4%; 43.9% and 49.4 ± 35.7; 50.3 ± 33.4 h respectively). The most frequent complications were extravasation (47.0%) and phlebitis (5.9%). Just one attempt was needed for 63.8% of cannulations of the dorsal hand, followed by 38.9% in the forearm. No significant differences were found in fixation type, sex, weight, gestational age or infusion type (continuous/intermittent).

Conclusions: The success of the technique is low. The preferred insertion sites with fewer complications, longer duration and fewer attempts were the dorsal hand and cubital fossa. With fewer attempts required for cannulation, better results were achieved on the dorsal hand.

Introduction

Basic and intermediate neonatal care units are designed to manage stable or hospitalized patients to study or treat uncomplicated conditions that require non-invasive monitoring, surveillance and ongoing nursing management in addition to medical care (Novoa, Milad, Vivanco, Fabres, & Ramírez, 2009). The most frequent peripheral venous catheter insertion sites in neonatal patients are the dorsal hands and feet, the scalp and the cubital fossa (Danski, Mingorance, Johann, Veyego, & Lind, 2016; Hugill, 2016; Unbeck et al., 2015). The procedure is performed by nursing staff who are responsible for the insertion, maintenance and removal of the catheter (Consejo Internacional de Enfermeras - CIE, 2012). Peripheral venous catheterization in neonatal patients is not without risk; the technique requires qualification, knowledge, capability and mastery, as well as nursing care for maintenance. Even experienced nursing personnel may need more than one attempt to insert a peripheral venous catheter, with the average being 1.4 attempts (Gomes et al., 2011). The most frequent local complications are extravasation (in about 74% of cases) and phlebitis (in about 12%), which increase in frequency the lower the weight and gestational age of the newborn (Barria & Santander, 2006; Nercelles, Vernal, Brenner, & Rivero, 2015). These complications are one of the main variables studied in most of the published articles (Boyd, Aggarwal, Davey, Logan, & Nathwani, 2011; Cicolini et al., 2014; Cicolini, Bonghi, Di Labio, & Di Mascio, 2009; Serane & Kothendaraman, 2016).

Regarding catheter maintenance, it should be noted that continuous perfusion requires more time and attention on the part of the nursing team and makes it difficult for the mother to have access to the child. On the other hand, keeping the catheter closed (intermittent administration) can shorten the life of the cannula and cause obstruction due to coagulation of the tip of the cannula. There are no studies with significant results to determine whether or not maintenance of the peripheral route requires continuous maintenance fluid therapy (Arnts et al., 2011;

* Corresponding author.
E-mail address: ernesto.cortes@umh.es (E. Cortés-Castell).

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Perez, Feuz, Brotschi, & Bernet, 2012; Shah, Eugene, & Sinha, 2011). The duration and viability of peripheral venous catheters in neonates is short due to vein fragility, with a mean duration of 35 h (Jiménez-Pérez, Rodríguez-Rodríguez, García-Villanueva, & Revilla-Llarena, 2015) to 96 h (Unbeck et al., 2015). Use of the smallest gauge catheter possible is recommended in order minimize damage to the peripheral vascular system, making the installation durable and facilitating hemodilution (O'Grady et al., 2011).

Securing the peripheral venous catheter is also very important. The dressing must leave the insertion site visible to avoid unnecessary catheter changes, allow transpiration, but prevent the passage of liquids and microorganisms from the exterior to the skin. Tape should be able to be easily removed and leave no adhesive residue. Semi-permeable transparent dressings have become the most commonly used means of covering the catheter and the insertion site (Corredor-Cazcarro et al., 2018).

The main objective of this study was to determine the factors associated with the success or failure of the peripheral venous catheter technique in neonates, with success defined as its duration and the absence of associated complications.

Material and methods

Study population

The study included neonates hospitalized in the Neonatal Unit of Vinalopó University Hospital in Elche (Spain). The hospital covers an estimated population of 150,000 inhabitants with a mean of 1550 annual births. The unit is considered Level I-II B (Basic and Intermediate Care Unit), is equipped with eight boxes with incubators or cribs depending on the condition of the patient and has a mean of 205 admissions per year. It is a modern unit with state-of-the-art equipment to provide optimal patient care.

Study design and participants

The study design was descriptive, cross-sectional and associative and included all live newborns admitted to the unit who required peripheral venous catheterization, with ages from 0 to 28 days. Data collection was carried out over five complete years (2013–2017). All newborns whose guardians did not agree to data collection were excluded. Upon entering the unit, the guardian was given an information sheet detailing the process of collecting the study variable data.

Variables and measurements

The entire nursing staff of the neonatology unit of the hospital was involved, creating the NEOCAT working group (Acronym NEOnate - CATheter). NEOCAT was created to study the incidence of local complications and the viability of peripheral catheters in neonatology. NEOCAT comprises nurses specialized in neonatology and members of the neonatal intravenous therapy organization.

All the peripheral veins cannulated and the variables collected were recorded by the nurse responsible for the patient during each shift, using a record that was initiated upon insertion of the catheter and was updated until removal of the catheter. To standardize criteria, an information session was held beforehand for unit personnel on the correct fulfillment of the criteria. Subsequently, reinforcement sessions were held annually, as well as following the incorporation of new personnel into the unit. All participating personnel joined the NEOCAT working group.

Data collection distinguished between two types of variables: demographic variables, concerning the neonate, and procedural variables, associated with the technique and catheter used. Demographic variables included: sex, birth weight, gestational age, admission weight and age at the time of the procedure. Catheterization procedure variables included the following parameters that could indicate the success or failure of the technique: 1) number of venipuncture attempts by nursing staff (1, 2 or ≥3 attempts); 2) catheter duration, the time between catheter insertion and removal (hours); 3) reason for catheter removal: extravasation, phlebitis, occlusion, accidental removal and whether the catheter was removed at treatment completion.

The Maddox scale (González-Suárez, Argüelles-Martínez, & Martínez-Bueno, 2014) adapted to neonates was used to measure the degree of phlebitis. This scale scores the usual signs and symptoms detected to measure the four degrees of phlebitis:

- 0 no signs of local complication or pain.
- 1 discomfort or mild pain with no erythema or swelling.
- 2 pain with erythema and/or swelling with no palpable cord.
- 3 pain with erythema and/or swelling and palpable cord <6 cm.
- 4 pain with erythema and/or swelling and palpable cord >6 cm.
- 5 pain with erythema and/or swelling, palpable cord and signs of venous thrombosis. Phlebitis is defined as a score of 2 or higher on the scale and is used to determine catheter removal. The pain was measured with the CRIES SCORE which includes domains of crying, requires increased oxygen administration, increased vital signs, expression and sleeplessness (Krechel & Bildner, 1995).

The variable regarding catheter success was defined as those catheters in which there were no local complications (extravasation or phlebitis), no obstruction or accidental extraction, and catheter removal was at treatment completion.

We also collected variables concerning the type of procedure performed, considering the insertion site, back of the hand, forearm, cubital fossa, foot and scalp; peripheral venous catheter size according to the gauge scale 24G (0.7 × 19 mm), 26G (0.6 × 19 mm) and the 24G butterfly Intima™; type of connector (double-lumen 'Y' type extension set with two Alaris® SmartSite® needle-free connectors, three-way stopcock with one free access port and one Alaris® SmartSite® needle-free connector, or the Alaris® SmartsSite® needle-free connectors alone); type of fixation, chevron technique with crossed adhesive strips over and parallel to the catheter insertion point; and type of therapy, recording intravenous medication and/or fluid therapy administered to the neonatal patient.

In all cases, asepsis of the venipuncture site was performed following organization protocols using aqueous chlorhexidine 2%. Additionally, no routine catheter replacements were performed without being clinically indicated (Bueno, Álvarez-Alonso, & Capell-Sada, 2012; Rickard et al., 2012; Rivas-Lienqueo & Rivas-Riveros, 2008; Ullman, Keogh, Marsh, & Rickard, 2015).

Statistical analysis

Previous calculation of sample size was not used, as all the available sample was used for five consecutive years. The sample size was considered to be appropriate when the premises stated in the objectives could be established.

Quantitative variables were described using means and standard deviations. Qualitative variables were described by absolute and relative frequencies. In the bivariate analysis, regarding the success/failure variables, Student's *t*-test or nonparametric analyses were performed depending on normality in the quantitative variables, and the chi-square test was used for the qualitative variables. Binary logistic regression analysis of success/failure was performed to eliminate possible confounding variables. The level of significance was set at $p < 0.05$. The statistical package used was SPSS version 25.0.

Ethical issues

The NEOCAT project was previously approved by the Research and Bioethics Committee of the Department of Health of Vinalopó and Torrevieja, complying with all quality, safety and data protection

requirements established by the organization. Data processing was completely anonymous at all times.

Results

During the study period, 967 peripheral catheters were cannulated in the unit. A total of 38 catheters (3.9%) were excluded because they did not meet the inclusion criteria or because the record could not be completed due to transfer of the neonate to another hospital. Thus, the study comprised 929 infants with catheters.

The descriptive data of the sample are displayed in the second column of Table 1. Of the neonates analyzed, 415 were girls (44.7%) and 514 boys (54.3%), with a mean weight of 3021 ± 709 g and a mean gestational age of 38.4 ± 4.4 weeks. The mean duration of all the catheters was 46.5 ± 33.9 h. The preferred catheter type was the 26G in 81.9% of the cases, followed by the 24G butterfly in 12.1% and the 24G short in 6.0%. In 47.1% ($n = 438$) of the cases, the nurse inserted the catheter on the first attempt, 25.5% ($n = 237$) required a second attempt, and 27.7% ($n = 254$) required three or more attempts. Securing the cannula without a chevron was the preferred fixation technique in 93.8% of the cases. Additionally, 90.0% ($n = 836$) of the catheters were used with a 'Y' type extension connector. The remaining connectors, such as the three-way stopcock ($n = 49$; 5.3%) and the needle-free connector alone ($n = 44$; 4.7%) were the least used. Continuous infusion was used in 65.8% of the catheters ($n = 611$).

The next columns in Table 1 list catheter insertion by preferred site, which was primarily the back of the hand (48.2%), followed by the cubital fossa (20.1%), forearm (16.9%), foot (12.7%), and the scalp (2.0%). Comparison of the variables by insertion site showed that catheter duration varied significantly ($p < 0.001$), with longer duration observed in the cubital fossa (50.3 ± 33.4 h) and the back of the hand (49.4 ± 35.7 h).

The number of attempts, expressed as the ease of cannula insertion, revealed the most easily cannulated site (attempts = 1) to be the back of the hand, with 63.8% ($n = 286$) success. This site was 35.5% more successful than the total mean. Conversely, the scalp was the most difficult, with a greater number of attempts needed to achieve insertion. In 84.2% of the cases, at least three attempts were required. Analyzing the rest of the sites, we found that successful cannulation was achieved on the first attempt in the forearm in 38.9% ($n = 61$), in the cubital fossa in 34.8% ($n = 65$), and in the foot in 20.3% ($n = 24$%) (Fig. 1).

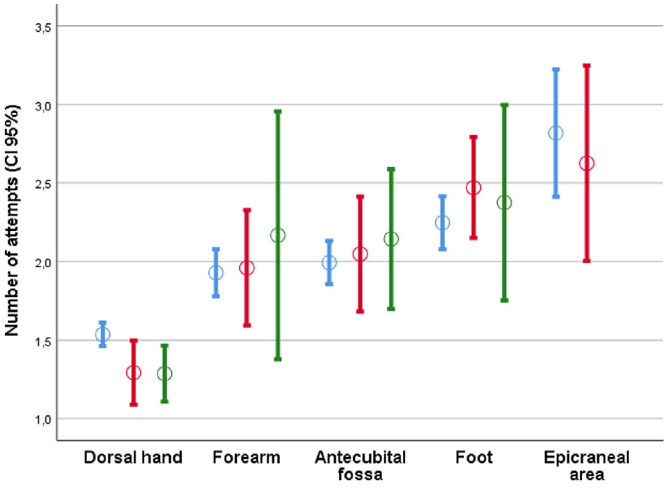

Fig. 1. Number of catheter insertion attempts by insertion site. Type of catheter: blue, 26G short; red, 24G butterfly and green, 24G short.

For all sites, the main reason for cannula removal was a local complication. Extravasation was the primary cause in 47.0% of the cases ($p = 0.017$). The site with the highest number of complications was the foot, with the highest incidence of extravasations (56.8%). The second most frequent local complication in all sites, except the foot where catheter obstruction was higher, was phlebitis (5.9%). No potentially serious cases were detected, with all cases being detected in the initial stages (presence of pain, inflammation or erythema, with a score on the

Table 1
Characteristics of the sample and its distribution according to catheter insertion site in the neonates analyzed.

Variable	Total 929 (100) *n* (%); mean ± SD	Dorsal hand 448 (48.2) *n* (%); mean ± SD	Forearm 157 (16.9) *n* (%); mean ± SD	Cubital fossa 187 (20.1) *n* (%); mean ± SD	Foot 118 (12.7) *n* (%); mean ± SD	Scalp 19 (2.0) *n* (%); mean ± SD	*p*-Value
Weight (g)	3021 ± 709	2993 ± 692	2988 ± 716	2996 ± 707	3187 ± 743	3163 ± 741	0.083
Gestational age (weeks)	38.4 ± 4.4	38.2 ± 4.1	38.9 ± 6.1	38.3 ± 4.5	38.3 ± 2.5	38.6 ± 2.8	0.313
Duration (hours)	46.5 ± 33.9	49.4 ± 35.7	40.0 ± 30.4	50.3 ± 33.4	39.1 ± 29.2	41.5 ± 36.7	<0.001
Girls	415 (44.7)	196 (43.8)	66 (42.0)	83 (44.4)	56 (47.5)	14 (73.7)	0.114
Gauge:							
26G	761 (81.9)	379 (84.6)	126 (80.3)	152 (81.3)	93 (78.8)	11 (57.9)	<0.001
24G winged	112 (12.1)	41 (9.2)	25 (15.9)	21 (11.2)	17 (14.4)	8 (42.1)	
24	56 (6.0)	28 (6.3)	6 (3.8)	14 (7.5)	6 (5.1)	0	
Parallel fixation	871 (93.8)	416 (92.9)	152 (96.8)	173 (92.5)	112 (94.9)	18 (94.7)	0.416
Attempts:							
1	438 (47.1)	286 (63.8)	61 (38.9)	65 (34.8)	24 (20.3)	2 (10.5)	<0.001
2	237 (25.5)	101 (22.5)	44 (28.0)	55 (29.4)	36 (30.5)	1 (5.3)	
≥3	254 (27.3)	61 (13.6)	52 (33.1)	67 (35.8)	58 (49.2)	16 (84.2)	
Connector:							
Stopcock	49 (5.3)	20 (4.5)	9 (5.7)	11 (5.9)	6 (5.1)	3 (15.8)	0.019
Extension	836 (90.0)	415 (92.6)	136 (86.6)	168 (89.8)	104 (88.1)	13 (68.4)	
Needle-free connector	44 (4.7)	13 (2.9)	12 (7.6)	8 (4.3)	8 (6.8)	3 (15.8)	
Reason for removal:							
Obstruction	37 (4.0)	12 (2.7)	9 (5.7)	6 (3.2)	9 (7.6)	1 (5.3)	0.017
Extravasation	437 (47.0)	204 (45.5)	77 (49.1)	81 (43.3)	67 (56.8)	8 (42.1)	
Phlebitis	55 (5.9)	20 (4.5)	14 (8.9)	12 (6.4)	8 (6.8)	1 (5.3)	
Accidental	44 (4.7)	22 (4.9)	7 (4.5)	6 (3.2)	7 (5.9)	2 (10.5)	
End of treatment	356 (38.3)	190 (42.4)	50 (31.9)	82 (43.9)	27 (22.9)	7 (36.8)	
Continuous infusion	611 (65.8)	276 (61.6)	103 (65.6)	135 (72.2)	82 (70.1)	15 (78.9)	0.054

n, absolute frequency; %, relative frequency; SD, standard deviation.
p-Value test Kruskal-Wallis.

Maddox scale of 2). The number of cases of phlebitis was the highest in the forearm (8.9%) and the lowest in the back of the hand (4.5%). Accidental removals (4.7%) and catheter obstruction (4.0%) were the next most common reasons for removal.

Table 2 summarizes the bivariate analysis and binomial logistic regression for the variables associated with success or failure of intravenous catheterization. Success with the technique, described as catheter removal upon completion of treatment, was 38.3% ($n = 356$). Success was higher in the catheters placed in the cubital fossa (43.9%; $n = 82$) and the back of the hand (42.4%; $n = 190$). Below the mean were those inserted in the scalp (36.8%; $n = 7$), forearm (31.9%; $n = 50$) and foot (22.9%; $n = 27$).

Results of the comparison of successful and unsuccessful catheters using Student's *t*-test for quantitative variables and Chi-square test for qualitative variables were significant for the site ($p < 0.001$) and duration ($p < 0.001$) and close to significance for the number of attempts ($p = 0.065$). Both the back of the hand and the cubital fossa had a higher probability of success than the rest of the sites studied. We also noted that with a greater number of attempts the probability of success decreased. Results of the binomial logistic regression model of the success of cannulization in relation to the other variables analyzed only the duration of the catheter was significant ($p < 0.001$). The mean duration of all the catheters was 46.5 ± 33.9 h and for the catheters classified as successful this was 28.8% higher (59.9 ± 37.7 h) (Table 2).

Table 3 describes the characteristics according to the type of catheter used in the cannulization. The most commonly chosen catheter was the 26G short in 81.9% ($n = 761$) of the cases, followed by the 24G butterfly (12.1%; $n = 112$), and the 24G short (6.0%; $n = 56$). The preferred insertion site for all three cannula types was significant ($p = 0.001$), with the chosen location being the back of the hand. Catheter duration was not significantly affected by the type used, and was slightly longer in 24G short catheters (52.7 h) ($p = 0.094$). The complications that occurred with regard to the catheter used were similar to the mean, with extravasations being the main reason for removal as well as the most common complication.

Table 3
Duration, insertion site, number of attempts and reason for removal according to the type of catheter used in the neonates analyzed.

Variable	26G 761 (81.9) *n* (%); mean ± SD	Winged 24G 112 (12.1) *n* (%); mean ± SD	24G 56 (6.0) *n* (%); mean ± SD	*p*-Value
Duration (h)	46.4 ± 33.4	44.6 ± 36.4	52.7 ± 34.2	0.094
Site:				
Dorsal hand	379 (49.8)	41 (36.6)	28 (50.0)	0.001
Forearm	126 (16.6)	25 (22.3)	6 (10.7)	
Cubital fossa	152 (20.0)	21 (18.8)	14 (25.0)	
Foot	93 (12.2)	17 (15.2)	8 (14.3)	
Scalp	11 (1.4)	8 (7.1)	0 (0)	
Attempts:				
1	362 (47.6)	51 (45.5)	25 (44.6)	0.334
2	191 (25.1)	26 (23.2)	20 (35.7)	
≥3	208 (27.3)	35 (31.3)	11 (19.6)	
Removal:				
Obstruction	29 (3.8)	4 (3.6)	4 (7.1)	0.121
Extravasation	365 (48.0)	45 (40.2)	27 (48.2)	
Phlebitis	41 (5.4)	9 (8.0)	5 (8.9)	
Accidental	32 (4.2)	11 (11.8)	1 (1.8)	
End treatment	294 (38.6)	43 (38.4)	19 (33.9)	

n, absolute frequency; %, relative frequency; SD, standard deviation.
p-Value test Kruskal-Wallis and test χ^2.

Discussion

Comparison with the literature

Neonatal basic and intermediate care units are intended for the management of stable patients. In these units, intravenous therapy is a frequent procedure involving peripheral venous access. After a comprehensive review, we note that studies carried out on peripheral catheters

Table 2
Bivariate analysis and binomial logistic regression of intravenous catheter success.

Variable	Total sample 929 (100) *n* (%); mean ± SD	Success 356 (38.3) *n* (%); mean ± SD	*p*-Value*	OR_{adjust} (CI 95%)	*p*-Value**
Weight (g)	3021 ± 709	3026 ± 708	0.867	1.000 (1.000–1.000)	0.893
Gestational age (weeks)	38.4 ± 4.4	38.3 ± 2.4	0.590	0.973 (0.932–1.015)	0.199
Duration (h)	46.5 ± 33.9	59.9 ± 37.7	<0.001	1.020 (1.015–1.025)	<0.001
Girls	415 (44.7)	161 (38.8)	0.828	1.033 (0.774–1.378)	0.828
Site:					
Dorsal hand	448 (48.2)	190 (42.4)	<0.001	1.223 (0.425–3.518)	0.710
Forearm	157 (16.9)	50 (31.8)		0.895 (0.305–2.623)	0.840
Cubital fossa	187 (20.1)	82 (43.9)		1.243 (0.430–3.595)	0.688
Foot	118 (12.7)	27 (22.9)		0.532 (0.176–1.601)	0.261
Scalp	19 (2.0)	7 (36.8)		1	
Catheter:					
26G	761 (81.9)	294 (38.1)	0.783	1.261 (0.678–2.344)	0.464
24G butterfly	112 (12.1)	43 (38.4)		2.288 (0.968–5.408)	0.059
24G	56 (6.0)	19 (33.9)		1	
Fixation in chevron	58 (6.2)	24 (41.4)	0.621	1.317 (0.726–2.387)	0.365
Attempts:					
1	438 (47.1)	180 (41.1)	0.065	0.874 (0.607–1.260)	0.113
2	237 (25.5)	76 (32.1)		0.656 (0.436–0.987)	0.471
≥3	254 (27.3)	100 (39.4)		1	
Connector:					
Stopcock	49 (5.3)	12 (24.5)	0.115	0.681 (0.254–1.829)	0.446
Extension	836 (90.0)	328 (39.2)		1.802 (0.720–4.510)	0.208
Needle-free connector	44 (4.7)	16 (36.4)		1	
Continuous infusion	611 (65.8)	247 (40.4)	0.073	0.789 (0.578–1.076)	0.134

n, absolute frequency; %, relative frequency; SD, standard deviation.
* *t*-Student or Chi-square test.
** Test binary logistic regression model; Chi-square = 115.754; $p < 0.001$.

in these units alone are not common. All previous studies included neonates admitted to critical care units, alone or in conjunction with intermediate and basic care units. Additionally, the sample size was smaller than ours in all cases, although the sample of 828 catheters used by Barria PR, et al. in their 2006 study was nearly as large.

The data from other studies with similar sample sizes also showed a predominance of the male sex. The mean gestational age, also directly related to weight, was higher because in the study unit only infants born at >32 weeks of gestation are seen (Jiménez-Pérez et al., 2015). The duration of these catheters is varied and limited, ranging from <24 h in 50% of the catheters placed to 48 h in 65.7% and, according to the most recent data, up to 4 ± 0.3 days (Danski, Mingorance, Johann, & Schwanke, 2016; Gomes et al., 2011; Unbeck et al., 2015). The results of the present study showed lower values for the total of all catheters (46.5 h), although analysis of the successful catheters revealed more positive results, reaching 59.9 h.

The preferred cannulation site reported in the literature, as well as in our study, was the back of the hand, with similar results in 46.7% of the cases (Unbeck et al., 2015). Other studies grouped the venipuncture zones into the lower or upper limbs and the scalp, indicating that 87.3% of the catheters were cannulated in the upper limbs (Danski, Mingorance, Johann, & Schwanke, 2016; Danski, Mingorance, Johann, Veyego, & Lind, 2016).

In all the studies reviewed, 24G and 26G short or butterfly catheters were used. Although the 24G was used in 85.2% of the cases reported, in our setting this was only used in 6.0% of the cases and the 26G was used in 81.9%. Nonetheless, this point is not relevant since we have shown that the type of catheter has no influence on the other variables (Jiménez-Pérez et al., 2015). Cannulation is not considered an easy technique and requires the proper knowledge and training for its successful achievement. O'Grady et al. (2011) recommend that peripheral catheters should not be substituted in this type of patient when it is not clinically indicated, as no benefits or reduction in the number of complications are obtained by their systematic substitution, a recommendation we followed. This method also causes insertions to become increasingly difficult and reduces the number of cannulation sites and veins available, especially in cases of prolonged treatments. For longer treatments, O'Grady et al. (2011) also recommend the use of midline catheters when treatment exceeds 6 days. In our study, this type of catheter was not available.

In all the studies, successful cannulization was achieved in less than half of the cases, with the percentage of catheters removed at treatment completion ranging from 13.4%–18% (Barria & Santander, 2006; Gomes et al., 2011). These figures have subsequently been surpassed, with values reaching 45.9%, slightly higher than the 38.6% achieved in our study (Unbeck et al., 2015). The most frequent local complication and reason for catheter removal is extravasation, accounting for 74.1% of cases and phlebitis in 3.7%, although phlebitis, a more dangerous complication, can reach 12% (Barria & Santander, 2006; Nercelles et al., 2015). In our study, phlebitis occurred in 5.9% of the cases. This study also reported that 12% of all catheter-associated bacteremias originated from peripheral venous catheters, with the majority caused by *Staphylococcus aureus*, *Klebsiella pneumoniae* and *Staphylococcus coagulase-negative* (Nercelles et al., 2015).

The number of insertion attempts was not analyzed in all studies. Barria et al. in 2006 obtained a rate of 1.48 attempts per catheter, achieving insertion on the first attempt in 66.9% of the cases. In the present study, the measurement system was different in that the number of attempts was limited, and a rate could not be obtained. The results were lower, with 47.1% of insertions achieved on the first attempt.

In our study, the purpose of catheter use was separated into continuous intravenous treatment or intermittent medication. Danski, Mingorance, Johann, and Schwanke (2016) showed that the use of the catheter in the administration of basic plan increases by 1.24 times the risk of developing complications ($p = 0.003$), increasing by 1.33 times in cases of parenteral nutrition administration ($p < 0.001$). Peripheral catheters were not used to administer parenteral nutrition, in accordance with hospital protocols, which require a central intravenous line. Jiménez-Pérez et al. (2015) reported the main uses of the catheter were for the administration of fluid therapy (55.9%), followed by the administration of antibiotics, the most frequent being ampicillin (55.2%) and gentamicin (55.2%).

Strengths and limitations

An important strength of this study is the number of patients analyzed, as this was one of the largest series studied to date. An additional strength is the statistical analysis which used multivariate analysis, thereby eliminating the possible biases produced by variables that may act as confounders. A final strength is the consistency in performance by the entire nursing team, all of whom had been previously trained and had at least 2 years of experience in neonatal nursing, thus minimizing errors in data collection. As a novel element, the analysis was performed on a specific group of patients, neonates hospitalized in the basic or intermediate care unit, in comparison with most of the studies analyzed, which also included neonates in intensive care. For this reason, the NEOCAT study provides specific results from the general neonatal population.

Among the limitations, we note that we were unable to monitor 3.9% of the catheters cannulated in our unit due to patient transfer to the intensive care unit of the reference hospital of the area. Furthermore, the cause of phlebitis could not be analyzed because the catheter tips were not sent for microbiological evaluation. Therefore, we were unable to determine whether the etiology was bacterial, mechanical or chemical. We did not consider establishing a relationship between length of stay and diagnosis at admission with the number of days of intravenous therapy required. However, in all cases the required days of prescribed intravenous treatment were completed. Finally, although catheter fixation was examined with and without the chevron method, the use of an immobilizing splint in the upper or lower limbs was not taken into account. Nevertheless, according to the protocol of the unit, a splint is routinely used to maintain limb immobilization.

Implications for clinical practice

Based on the results of the present study and in accordance with the recommendations of the CDC (Centers for Disease Control and Prevention) and the rest of the studies analyzed, we recommend the upper limbs for peripheral catheter placement, specifically on the dorsal hand and in the cubital area, sites with the fewest complications. With regard to the ease of cannulation, measured by the least number of attempts, we found the area of the dorsal hand to be statistically significant. We therefore recommend, as the first option, catheter placement on the dorsal hand in neonates. Concerning the choice of the type of catheter, no statistical differences were obtained in comparison with the three main variables, although there is strong evidence that recommends selecting the type of catheter according to its indication and considering the smallest possible size. Nor were significant results obtained regarding the use of a particular type of connector or fixation, with the transparent dressing being used in its entirety, and in most cases not using dressings that covered the insertion point. In addition, as a measure to prevent mechanical phlebitis, the use of an extension set is recommended (O'Grady et al., 2011). It could be interesting to investigate the influence on success of the type of medication, as well as other possible factors, depending on the cannulation technique, in order to reduce the number of failures, with the consequent harm to the newborn and distress to the family.

Conclusion

The most relevant variables for determining catheter viability were catheter duration, success and fewer complications, together with

ease of insertion. The success of the technique was low, occurring in 38.3% of the cannulations. The mean catheter duration was 46.5 h and was longer (59.9 h) in the catheters removed at the completion of treatment. The most frequent reason for removal was a local complication, with extravasation being the primary reason (47.0%). The preferred sites due to fewer complications and longer duration were the back of the hand and cubital fossa. In terms of ease, measured by the number of attempts at insertion, the back of the hand was preferred.

Conflicts of interest

No conflict of interest has been declared by the author(s).

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Author contribution table

Criteria	Author initials
Made substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data;	DMO; MMRB; CMP; ECC
Involved in drafting the manuscript or revising it critically for important intellectual content;	DMO; MMRB; CMP; ECC
Given final approval of the version to be published. Each author should have participated sufficiently in the work to take public responsibility for appropriate portions of the content;	DMO; MMRB; CMP; ECC
Agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.	DMO; MMRB; CMP; ECC

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