REUE | Original Article

Ultrasound-guided peripheral venous cannulation: technique and complications in comparison with conventional techniques

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OBJECTIVES. To describe the use of ultrasound-guided peripheral venous cannulation in an emergency department (ED). To compare the incidence of complications with this technique to those in conventional placement of an intravenous line.

METHODS. Observational, descriptive, retrospective study in the ED of Hospital Universitario de Cabueñes in Spain. We collected data on 108 cannulation attempts in adults with difficult venous access, recording success or failure of placement, characteristics of the punctured vein, time the catheter remained in place, and the reason for removal. The incidence of complications was calculated and compared to the findings of our earlier study on traditional venous line placement.

RESULTS. Venous access was successful in 86.1% of the cases. Out-of-plane imaging was used in the majority of attempts (80.6%). Placement was in the basilica vein in 52.7%, and at a mean (SD) depth of 6.2 (2.2) mm. The mean venous diameter was 4.5 (0.9) mm, and 35 catheters remained in place 24 hours on average. Complications occurred in 12 of the 35 (34.2%). Extravasation (in 14.2%) was the most frequent complication; phlebitis developed in 5.7%. Fewer cases of obstruction occurred with ultrasound guidance than with the traditional technique. There were no differences with respect to the incidences of phlebitis, extravasation, or accidental removal. No associations were found between any variables (catheter, vein accessed, depth, or diameter) and time the catheter was in place or the reason for removal.

CONCLUSIONS. Ultrasound-guided peripheral venous cannulation is a useful technique in patients with difficult venous access. Complications are no more frequent than with the conventional technique for placement of a venous line.

Keywords: Ultrasound guidance. Peripheral venous access. Difficult venous access. Nursing care. Emergency services.

Canalización venosa periférica ecoguiada: características y complicaciones comparadas con técnica tradicional

OBJETIVOS. Describir la experiencia en la canalización de catéteres periféricos ecoguiados en un servicio de urgencias (SU), y conocer la incidencia de complicaciones en estos catéteres comparando con la técnica tradicional.

MATERIAL Y MÉTODO. Estudio observacional, descriptivo y retrospectivo en un SU hospitalarias. Se recogieron datos de 108 intentos de canalización en pacientes adultos con vía venosa difícil. Se valoró el éxito o fracaso en la canalización, características de la vena puncionada, duración del catéter y motivo de retirada. Se calculó la incidencia de complicaciones y se comparó con el estudio en catéteres tradicionales ENSINFLEBIT.

RESULTADOS. El éxito en la canalización fue del 86,1%. La mayoría de las punciones se hicieron con técnica fuera de plano (80,6%), en vena basílica (52,7%), a una profundidad media de 6,2 mm (± 2,2) y con un diámetro medio de vena de 4,5 mm (± 0,9), 35 catéteres permanecieron más de 24 horas, de los cuales 12 (34,2%) sufrieron complicaciones. La complicación más frecuente fue la extravasación (14,2%) y la proporción de flebitis fue de 5,7%. Con la técnica ecoguiada hubo menos casos de obstrucción que con técnica tradicional. No hubo diferencias en cuanto a flebitis, extravasación y retirada accidental. No se encontró relación entre las variables catéter, vena, profundidad y diámetro, y la permanencia y motivo de retirada.

CONCLUSIONES. La canalización venosa periférica ecoguiada es una técnica útil en pacientes con vía venosa difícil. La incidencia de complicaciones no es mayor que con la técnica tradicional.

Palabras clave: Ultrasonido. Catéter venoso periférico. Acceso venoso difícil. Cuidados de enfermería. Atención de urgencias.

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Introduction

The placement of a peripheral venous line is one of the basic and essential procedures in a emergency department (ED). At times, patients present with personal characteristics that make cannulation difficult, leading to multiple punctures, difficulty obtaining samples, delays in diagnosis, delays or limitations in treatments, and, in some cases, the need to place a central line. All of this results in increased patient risks and harm,[1] higher economic costs, and feelings of frustration among nursing professionals.[2]

These patients are defined as DIVA (difficult intravenous access) patients, and it is estimated that they may represent up to 8.3% of patients who come to an ED,[3] giving us an idea of the magnitude of the problem.

In recent years, the use of ultrasound to assist venous access placement has proven to be an effective resource, and its use is becoming increasingly widespread.[4,5] This expansion has been supported by technological advances that have made higher-quality, smaller, and more affordable ultrasound devices available, leading to the now widely used terms "bedside ultrasound" or "point-of-care ultrasound".[6] Although the use of ultrasound to assist the placement of peripheral venous catheters is a more recent technique vs central venous catheterization it is growing in Spain and across the world, as demonstrated by the number of publications in recent years in our country, its inclusion in clinical guidelines[7,8] and in hospital[2], intensive care unit,[9] and emergency department protocols,[10] as well as by the interest it generates in scientific conferences.

The use of this technique has been shown to reduce the number of punctures,[4-11] complications, the need for central venous access, and costs,[12,13] in addition to producing greater satisfaction among both patients and professionals[14,15] compared with traditional methods. Furthermore, it expands the number of venous options available for puncture, granting access to veins that would never have been attempted using the traditional blind technique, thereby preventing and delaying depletion of the patient's venous capital.[16]

In Spain, more than one-third of peripheral venous catheters are removed due to complications, primarily extravasation, followed by phlebitis.[17] Studies on complications of ultrasound-guided peripheral catheters conducted to date have not reached unanimous conclusions. Some have found no significant differences,[4-18] while others show a slight advantage for the ultrasound-guided technique.[19,20] These discrepancies have prevented the assertion that ultrasound-guided cannulation results in fewer complications.

Research to date has accumulated robust evidence on the superiority of the ultrasound-guided technique over the traditional technique in terms of cannulation success rates. Studies published in recent years seem to indicate that new lines of research are directed toward the expansion of the technique to pediatric patients,[15-21] toward training professionals in the ultrasound-guided technique,[22,23] and toward the use of longer catheters that promote catheter dwell time within the vein.[24,25]

The primary endpoint of this study is to describe the characteristics of the ultrasound-guided peripheral catheterization technique in an ED when performed by an operator experienced in the traditional technique but without previous knowledge of the ultrasound-guided technique and after receiving brief prior training. A secondary objective is to determine the incidence of complications in these catheters and compare them with those of the traditional technique.

Material and method

We conducted an observational, retrospective, descriptive study in the ED of a hospital that manages approximately 100,000 emergency visits per year.

Data were collected from ultrasound-guided cannulations performed from November 2018 through May 2021. The technique was always performed by the same operator, who had no prior experience in ultrasound-guided cannulation and received one hour of prior training on the use of the ultrasound device and the ultrasound-guided technique.

Sampling was carried out using non-probabilistic convenience sampling, including patients who met the inclusion criteria and for whom the operator was available at that time. Patients older than 18 years were included if they had clinical characteristics making venous access difficult (obesity, diabetes, IV drug use, edema, chemotherapy, prior history of difficulty), after two failed attempts using the traditional technique, or in cases where no visible or palpable vein was detected after applying a tourniquet. Patients in a life-threatening emergency and those who declined the technique were excluded.

After an ultrasound examination of both upper limbs, the vein considered most suitable was selected. Cannulation was performed using an aseptic peripheral catheterization technique according to department protocol, with alcohol or chlorhexidine as disinfectant, non-sterile conductive gel, and the ultrasound probe covered with a sterile transparent dressing. Successful cannulation was defined as the ability to extract 5 mL of blood and to infuse normal saline through the catheter without resistance.

Clinical characteristics of the patients (age, sex, previous conditions), characteristics of the cannulated vein (depth, diameter), technical characteristics (puncture plane, catheter used, success in cannulation, number of attempts required), catheter dwell time, and reason for removal were recorded. Relations between the independent variables—selected vein, catheter gauge, depth, and diameter—and the dependent variables—reason for removal and dwell time—were analyzed. Reasons for removal included: extravasation, obstruction, phlebitis, and accidental withdrawal.

A descriptive analysis was performed using the R software (R Development Core Team). Relative and absolute frequency distributions were calculated for qualitative variables, and measures of central tendency and dispersion were calculated for quantitative variables. Relationships between qualitative variables were evaluated using Fisher's exact test, with a significance level of 0.05.

To analyze complications of ultrasound-guided catheters, only those catheters that remained in place for more than 24 hours were considered. Results were compared with those of the ENSINFLEBIT study on catheters inserted using the traditional technique,[17] both at the national level and at the level of our hospital and our own department. The comparison between the ENSINFLEBIT study and ours was again carried out using Fisher's test with a significance level of 0.05, comparing the frequencies of complications—extravasation, obstruction, accidental removal, and phlebitis—in both studies.

To ensure patient anonymity, each patient was assigned a code, and no personal data were collected. This study was approved by the Ethics and Research Committee of the Principality of Asturias and the Research Commission of the Management of Area V.

Results

A total of 108 ultrasound-guided cannulations were performed; 81.4% (n = 88) were women, with a mean age of 75 years (± 16 years). The success rate was 86.1% (n = 93), and in 75.3% (n = 70) success was achieved on the first attempt. A total of 80.6% (n = 75) of punctures were performed using the "out-of-plane" technique. The basilic vein was selected in 52.7% (n = 49) of punctures. The mean depth of the vein at the puncture site was 6.2 (± 2.2 mm), and the mean diameter of the veins was 4.5 (± 0.9 mm).

The mean dwell time of successfully cannulated catheters was 2.4 (± 2.5 days). Of the total number of successfully cannulated catheters, 66.7% (n = 62) were removed because treatment had ended, and 23.6% (n = 22) had to be removed due to complications. Table 1 shows all results related to ultrasound-guided technique characteristics, vein characteristics, catheter dwell time, and complications.

Of the 35 catheters (37.6%) that remained in place for more than 24 hours, 12 (34.2%) experienced complications. The most frequent complication was extravasation at 14.2% (n = 5), followed by accidental removal at 8.5% (n = 3). The phlebitis and obstruction rates in these catheters were identical, 5.7% (n = 2) in both cases.

When comparing the complication rates found in our study with those reported in the ENSINFLEBIT study, significant differences were found in the percentage of obstruction (5.7% in ultrasound-guided vs 8.0% in the hospital, 13.3% in the ED with the traditional technique, and 5.6% in ENSINFLEBIT; $P < .001$). No significant differences were found regarding extravasation, phlebitis, or accidental removal between the different studies compared. The phlebitis rate with the ultrasound-guided technique was similar to that obtained with the traditional technique in the ED (5.7% vs 5.9%) and lower than that of Hospital de Cabueñes (Asturias, Spain) and the national level (8.6% and 8.5%, respectively). The extravasation rate was lower with ultrasound guidance than with the traditional technique in the ED (14.2% vs. 18.5%) and similar to that of our hospital and at the national level (14.7% and 14.4%, respectively). The results for each type of complication can be found in Table 2.

Table 1. Characteristics of ultrasound-guided peripheral venous cannulation

Cannulation attempts	N = 108	%
Success	93	86.1
Failure	15	13.9
Number of attempts for successful cannulation	N = 93	%
1	70	75.3
2	18	19.3
3 or more	5	5.4
Technique used	N = 93	%
Out-of-plane	75	80.6
In-plane	18	19.4
Catheter	N = 93	%
20G (32 mm length)	47	50.5
18G (45 mm length)	44	47.3
16G (50 mm length)	2	2.2
Cannulated vein	N = 93	%
Basilic	49	52.7
Cubital fossa	25	26.9
Antebrachial	10	10.8
Cephalic	9	9.6
Depth	N = 93	%
< 5 mm	31	33.3
5–10 mm	55	59.1
> 10 mm	7	7.5
Diameter	N = 93	%
< 4 mm	25	26.9
4–6 mm	66	71.0
> 6 mm	2	2.2
Dwell time	N = 93	%
< 24 hours	49	58.3
24–48 hours	12	14.3
48 hours–7 days	16	19.0
> 7 days	7	8.3
Not recorded	9	-
Reason for removal	N = 93	%
End of treatment	62	66.7
Accidental	7	7.5
Obstruction	3	3.2
Extravasation	9	9.7
Phlebitis	3	3.2
Not recorded	9	9.7
Complications in catheters > 24 hours	N = 35	%
Accidental removal	3	8.57
Obstruction	2	5.71
Extravasation	5	14.28
Phlebitis	2	5.71
Removal without complications	23	65.71

G: gauges; mm: millimeters.

Regarding the relationship between qualitative variables, no association was identified between the reason for removal—phlebitis, extravasation, obstruction, or accidental removal—and catheter type, selected vein, depth, or diameter. No association was identified between catheter dwell time and catheter type, selected vein, depth, or diameter. These results are shown in Table 3.

Discussion

The use of ultrasound for the cannulation of peripheral venous lines in patients with difficult venous access may represent a qualitative improvement in healthcare. Our aim was to implement this technique in our department and to

Table 2. Incidence proportion of complications in peripheral venous catheters. Data from Hospital de Cabueñes from the ENSINFLEBIT 2021 Study

Catheter complications	ENSINFLEBIT 2021 (n = 8.435)	Hospital (n = 649)	ED – traditional technique (n = 135)	ED – ultrasound-guided (n = 93)	*P* value
Extravasation	14.4%	14.7%	18.5%	14.2%	.610
Phlebitis	8.5%	8.6%	5.9%	5.7%	.726
Obstruction	5.6%	8.0%	13.3%	5.7%	< .001
Accidental removal	12.7%	11.7%	5.9%	8.5%	.079

understand the characteristics and factors involved in ultrasound-guided cannulation.

The results we obtained are consistent with most of the research accumulated to this date. The effectiveness of ultrasound-guided peripheral cannulation and its superiority over the traditional method has already been demonstrated by Van Loon *et al.*,[4] who, after analyzing data from eight studies totaling 1,660 patients, concluded that the ultrasound-guided technique achieves a higher success rate in cannulation than the traditional technique, reduces the number of attempts required, and increases patient satisfaction. Salleras-Duran and Fuentes-Pumarola[26] conducted a meta-analysis of 21 studies and found a success rate above 80% for ultrasound-guided puncture. In our study, the success rate was similar to that reported by these authors.

The ultrasound-guided cannulation technique has a learning curve, as do all new techniques. Our experience reflects that with basic knowledge of ultrasound operation, venous anatomy, and puncture technique, reasonable success rates can be achieved in a short period of time. Breslin *et al.*[22] used a sample of newly graduated physicians without prior ultrasound training and found that with only two hours of training in ultrasound-guided cannulation, the success rate in the following 3 months was 73%.

Most of the veins cannulated had a diameter > 4 mm, were located between 5 and 10 mm in depth, and were cannulated using the out-of-plane technique (recommended for operators without experience[2,9]). Witting *et al.*[27] showed that success rates were higher when the selected vein had a diameter of at least 4 mm and that difficulty increased significantly when the vein was located at < 3 mm or > 15 mm in depth.

Table 3. Relationships between catheter removal reason and catheter/vein characteristics and dwell time

Removal reason	Extravasation n (%)	Phlebitis n (%)	Not recorded n (%)	Obstruction n (%)	End of treatment n (%)	Accidental n (%)	*P* value
Catheter							.069
16G	0	0	1 (11.1)	0	1 (1.6)	0	
18G	4 (44.4)	0	5 (55.5)	3 (100)	26 (41.9)	6 (85.7)	
20G	5 (55.5)	3 (100)	3 (33.3)	0	35 (56.4)	1 (14.2)	
Vein							.336
Antebrachial	2 (22.2)	1 (33.3)	0	0	7 (11.2)	0	
Basilic	6 (66.6)	0	6 (66.6)	3 (100)	28 (45.1)	6 (85.7)	
Cubital fossa	1 (11.1)	1 (33.3)	2 (22.2)	0	20 (32.2)	1 (14.2)	
Cephalic	0	1 (33.3)	1 (11.1)	0	7 (11.2)	0	
Depth							.67
< 5 mm	1 (11.1)	1 (33.3)	3 (33.3)	1 (33.3)	23 (37.1)	2 (28.5)	
5–10 mm	7 (77.7)	2 (66.6)	5 (55.5)	1 (33.3)	35 (56.4)	5 (71.4)	
> 10 mm	1 (11.1)	0	1 (11.1)	1 (33.3)	4 (6.4)	0	
Diameter							.394
< 4 mm	3 (33.3)	1 (33.3)	0	1 (33.3)	17 (27.4)	3 (42.8)	
4–6 mm	6 (66.6)	2 (66.6)	8 (88.9)	2 (66.6)	44 (70.9)	4 (57.1)	
> 6 mm	0	0	1 (11.1)	0	1 (1.6)	0	

Permanence	< 24 h	24-48 h	48 h-7 d	> 7 d	*P* value
Catheter					
16G	0	0	1 (6.2)	0	
18G	19 (38.7)	7 (58.3)	9 (56.2)	4 (57.1)	.258
20G	30 (61.2)	5 (41.6)	6 (37.5)	3 (42.8)	
Vein					
Antebrachial	4 (8.1)	2 (16.6)	1 (6.2)	3 (42.8)	
Basilic	28 (57.1)	5 (41.6)	7 (43.7)	3 (42.8)	
Cubital fossa	11 (22.4)	4 (33.3)	7 (43.7)	1 (14.2)	.355
Cephalic	6 (12.2)	1 (8.3)	1 (6.2)	0	
Depth					
< 5 mm	17 (34.6)	2 (16.6)	6 (37.5)	3 (42.8)	
5–10 mm	31 (63.2)	9 (75.0)	7 (43.7)	3 (42.8)	.132
> 10 mm	1 (2.0)	1 (8.3)	3 (18.7)	1 (14.2)	
Diameter					
< 4 mm	14 (28.5)	3 (25)	4 (25)	4 (57.1)	
4–6 mm	35 (71.4)	9 (75)	11 (68.7)	3 (42.8)	.351
> 6 mm	0	0	1 (6.2)	0	

The basilic vein was the most frequently cannulated vein in this study. Various authors[28,29] agree that it is the optimal vein for puncture and is associated with a higher success rate because it is of good caliber, superficial, and not accompanied by other structures such as arteries and nerves, thus reducing the risk of injury.

Regarding catheter dwell time, most were removed before 24 hours, which corresponds to the typical ED patient profile, as most remain in the department only a few hours before discharge. Although some authors demonstrate an influence of depth and location on catheter dwell time,[24] no relationship was found between these variables in our study. Nevertheless, extravasation was the most frequent complication, and although one-third of the catheters (33.3%) were placed in veins less than 5 mm deep, only one extravasation incident (11.1%) occurred within this range.

For the comparison of complications, the ENSINFLEBIT study was used as a reference. This study has been conducted annually for several years in our country as part of the multicenter Phlebitis Zero project and the National Antibiotic Resistance Plan,[30] and includes, among other data, complications of peripheral venous catheters. In 2021, the study collected data from 8,435 catheters from 65 Spanish hospitals. The comparison between ultrasound-guided cannulation in the ED, the ENSINFLEBIT study, the Hospital de Cabueñes, and our ED using the traditional technique showed similar complication rates across all groups, with no significant differences except in obstruction, which had a lower incidence in the first two. The phlebitis rate was lower with the ultrasound-guided technique and very close to the internationally accepted standard of 5%.[30] Rates of extravasation and accidental removal were also always lower with the ultrasound-guided technique, and only in the case of obstruction was the national rate lower than the others. These data suggest that the ultrasound-guided technique is at least as safe as the traditional technique.

Our study has some limitations. The main limitation is that all punctures were performed by the same operator, which may have influenced the success rate due to individual skill. Second, catheter use, maintenance, and the types of drugs administered were not considered. Additionally, the small sample size may affect the validity of the results, and larger sample sizes would be necessary in future research to obtain more conclusive findings.

In conclusion, most cannulations were performed using the out-of-plane technique, in the basilic vein, with a vein diameter > 4 mm and a depth between 5 and 10 mm. Furthermore, compared with studies using the traditional technique, ultrasound-guided cannulation did not result in a higher number of complications. Larger studies are needed to further demonstrate the efficacy and safety of the ultrasound-guided technique.

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REFERENCES

1. Blanco-Mavillard I, Parra-García G, Fernández-Fernández I, Rodríguez-Calero MA, Personat-Labrador C, Castro-Sánchez E. Care of peripheral intravenous catheters in three hospitals in Spain: Mapping clinical outcomes and implementation of clinical practice guidelines. PLoS ONE. 2020;15:e0240086.
2. Gil Monte S, Pérez Navarro AM. Protocolo canalización de vía venosa periférica y punción arterial ecoguiada. Gerencia de Atención Integrada de Albacete, SESCAM. (Accessed 1 April 2019). Available at: http//www.chospab.es/publicaciones/protocolosEnfermeria/documentos/fc46edcfd850 2c01729e-4110c29e3378.pdf
3. Rodríguez Calero MA. Definiendo la vía venosa periférica de difícil canalización y los factores de riesgo asociados: revisión sistemática. Medicina Balear. 2019;34:11-9.
4. Van Loon FHJ, Buise MP, Claassen JJF, Dierick-Van Daele ATM, Bouwman ARA. Comparison of ultrasound guidance with palpation and direct visualisation for peripheral vein cannulation in adult patientes: a systematic review and meta-analysis. Br J Anaesth. 2018;121:358-66.
5. Tran QK, Fairchild M, Yardi I, Mirda D, Markin K, Pourmand A. Efficacy of Ultrasound-Guided Peripheral Intravenous Cannulation versus Standard of Care: A Systematic Review and Meta-analysis. Ultrasound Med Biol. 2021;47:3068-78.
6. Smallwood N, Daschsel M. Point-of-care ultrasound (POCUS): unnecessary gadgetry or evidence-based medicine? Clin Med (Lond). 2018;18:219-24.
7. Registered Nurses' Association of Ontario (RNAO). Vascular access. 2nd ed. Toronto (ON): RNAO; 2021.
8. Lamperti M, Biasucci DG, Disma N, Pittiruti M, Breschan C, Vailati D, et al. European Society of Anaesthesiology guidelines on peri-operative use of ultrasound-guided for vascular access (PERSEUS vascular access). Eur J Anaesthesiol. 2020;37:344-76.
9. Blanco P. Ultrasound-guided peripheral venous cannulation in critically ill patients: a practical guideline. USG. 2019;11:27.
10. Subdirección General de SAMUR. Manual de Procedimientos. Procedimientos asistenciales: SVA. Canalización de vías periféricas con ecografía. (Accessed 1 August 2022). Available at: http://www.madrid.es/ficheros/SAMUR/index.html
11. Salinas D, Sartain BJ, Sullivan JF, Moore CB, Hefley J. Implementation of ultrasound-guided peripheral intravenous practices in a multiple services unit. Medsurg Nurs. 2021;30:168-80.
12. Galen BT, Southern WN. Ultrasound-Guided Peripheral Intravenous Catheters to Reduce Central Venous Catheter Use on the Inpatient Medical Ward. Qual Manag Health Care. 2018;27:30-2.
13. Galen B, Baron S, Young S, Hall A, Berger-Spivack L, Southern W. Reducing peripherally inserted central catheters and midline catheters by training nurses in ultrasound-guided peripheral intravenous catheter placement. BMJ Qual Saf. 2020;29:245-9.
14. Bridey C, Thilly N, Lefevre T, Maire-Richard A, Morel M, Levy B, et al. Ultrasound-guided versus landmark approach for peripheral intravenous access by critical care nurses: a randomised controlled study. BMJ Open. 2018;8:e020220.
15. Vinograd AM, Chen AE, Woodford AL, Fesnak S, Gaines S, Elci OU, et al. Ultrasonographic Guidance to Improve First-Attempt Success in Children With Predicted Difficult Intravenous Access in the Emergency Department: A Randomized Controlled Trial. Ann Emerg Med. 2019;74:19-27.
16. Caballero MCC, Sánchez-Morago SG, del Río NT, Martín JC, Jiménez, BC. Actualización enfermera en accesos vasculares y terapia intravenosa. Asociación de Enfermería de Equipos de Terapia Intravenosa. Madrid: Difusión Avances de Enfermería; 2008.
17. Suárez MB. Grupo de trabajo Flebitis Zero. Resultados del "Estudio nacional de incidencia de flebitis asociada a catéter venoso peri-

férico" (ENSINFLEBIT 2021) en el contexto del Proyecto Multicéntrico Flebitis Zero. VIII Jornada Nacional Flebitis Zero. Oviedo. Noviembre 2021.
18. Desai K, Vinograd AM, Abbadessa MKF, Chen AE. Longevity and Complication Rates of Ultrasound Guided Versus Traditional Peripheral Intravenous Catheters in a Pediatric Emergency Department. JAVA. 2018;23:149-54.
19. Vinograd AM, Zorc JJ, Dean AJ, Abbadessa MKF, Chen AE. First-Attempt Success, Longevity, and Complication Rates of Ultrasound-Guided Peripheral Intravenous Catheters in Children. Pediatr Emerg Care. 2018;34:376-80.
20. Bahl A, Pandurangadu AV, Tucker J, Bagan M. A randomized controlled trial assessing the use of ultrasound for nurse-performed IV placement in difficult access ED patients. Am J Emerg Med. 2016;34:1950-4.
21. Mayordomo-Colunga J, González Cortés R, Bravo MC, Martínez Mas R, Vázquez Martínez JL, Renter Valdovinos L, et al. Ecografía en el punto de atención: ¿Es hora de incluirla en el programa de formación de especialistas en pediatría? An Pediatr. 2019;91:206.e1-206.e13
22. Breslin R, Collins K, Cupitt J. The use of ultrasound an adjunct to peripheral venous cannulation by junior doctors in clinical practice. Medical Teacher. 2018;40:1275-80.
23. Partovi-Deilami K, Nielsen JK, Moller AM, Neshein SS, Jorgensen VL. Effect of ultrasound-guided placement of difficult-to-place peripheral venous catheters: a prospective study of a training program for nurse anesthetists. American Associaton of Nurse Anesthetist. AANA J. 2016;84:86-92.
24. Pandurangadu AV, Tucker J, Brackney AR, Bahl A. Ultrasound-guided intravenous catheter survival affected by the amount of catheter residing in the vein. J Emerg Med. 2018;35:550-5.
25. Qin KR, Ensor N, Barnes R, Englin A, Nataraja RM, Pacilli M. Long peripheral catheters for intravenous access in adults and children: A systematic review of the literature. J Vasc Access. 2021;22:767-77.
26. Salleras-Duran L, Fuentes-Pumarola C. Cateterización periférica ecoguiada frente a la técnica tradicional. Enfermería Clínica. 2016; 26:298-306.
27. Witting M, Schenkel S, Lawner B, Euerle BD. Effects of vein width and depth on ultrasound-guided peripheral intravenous success rates. J Emerg Med. 2010;39:70-5.
28. Presley B, Isenberg JD. Acceso Intravenoso Guiado por Ultrasonido. Actualizado el 27 de junio de 2022. En: StatPearls [Internet]. Treasure Island (FL): Publicación de StatPearls; (Accessed 30 July 2022). Available at: https://www.ncbi.nlm.nih.gov/books/NBK525988/
29. Gottlieb M, Sundaram T, Holladay D, Nakitende D. Ultrasound-guided peripheral intravenous line placement: a narrative review of evidence-based best practices. Western J Emerg Med. 2017;18:1047.
30. Agencia Española de Medicamentos y Productos Sanitarios. Ministerio de Sanidad, Consumo y Bienestar Social. Plan Nacional de Resistencia Antibióticos. Prevención de complicaciones relacionadas con accesos vasculares de inserción periférica. Programa Flebitis Zero. Madrid. 2019. (Accessed 2 May 2022). Available at: https://www.resistenciaantibioticos.es/es/publicaciones/prevencion-de-complicaciones-relacionadas-con-accesos-vasculares-de-insercion