Colombian Journal of Anesthesiology

OPEN

Received: 30 November, 2023 ▸ Accepted: 18 June, 2024 ▸ Online first: 4 July, 2024

DOI: https://doi.org/10.5554/22562087.e1119

Right subclavian vein sonoanatomy from the supraclavicular fossa approach in children

Relaciones sonoanatómicas de la vena subclavia derecha desde la fosa supraclavicular en niños

David Santiago Giraldo Gutiérrez[a], Marco Antonio Bolívar Trujillo[a], Diego Armando Velásquez Granados[a], Jeiver Aldúbar Contreras Romero[b]

[a] Fundación Hospital de la Misericordia. Bogotá, Colombia.
[b] School of Medicine, Universidad Nacional de Colombia. Bogotá, Colombia.
Correspondence: Calle 44 # 59-75, Facultad de Medicina, Universidad Nacional de Colombia. Bogotá, Colombia.
E-mail: jecontrerasr@unal.edu.co

What do we know about this topic?

Central venous access is a valuable tool for delivering medications or for intraoperative monitoring. Although the internal jugular approach is considered the first choice, it entails several risks. Despite several notable advantages of the subclavian vein over the jugular and femoral veins due to the lower risk of late complications such as infection and thrombosis, it is not considered a first choice due to its proximity to the pleura and the subclavian artery.

What new contribution does the study make?

The supraclavicular approach to the subclavian vein in central venous catheterization has been shown to have a lower risk of complications when performed under ultrasound guidance, improving needle visualization and reducing the risk of pleural puncture.

How to cite this article:
Giraldo Gutiérrez DS, Bolívar Trujillo MA, Velásquez Granados DA, Contreras Romero JA. Right subclavian vein sonoanatomy from the supraclavicular fossa approach in children. Colombian Journal of Anesthesiology. 2024;52:e1119.

Abstract

Introduction: Although the subclavian vein offers significant advantages over other approaches for ultrasound-guided central venous access, it is not the first choice in the pediatric population, mainly due to its proximity to the pleura and the subclavian artery.

Objective: To assess the sonoanatomical characteristics of the subclavian vein and adjacent structures using the supraclavicular approach in a pediatric population.

Materials and methods: Observational, intraoperative, cross-sectional study, between June 2021 and March 2022. The population consisted of ASA I, II and III children taken to non-emergent surgical procedures under general anesthesia. Images were acquired with the patients under general anesthesia, using a high-frequency linear probe to identify the subclavian vein and measure the anatomical landmarks.

Results: A total of 67 children were recruited; mean age was 6 years (IQR: 2-12 years), with male sex predominance (61%). Median weight was 22 kg (IQR: 12.2-34 Kg) and median height was 115 cm (IQR: 88-142 cm). Measurements in relation to the vessel showed a mean distance from the skin of 0.70 cm (SD: 0.18 cm), while mean distance from the skin to the pleura was 1.31 cm (SD: 0.28 cm). Mean vein diameter was 0.49 cm (IQR: 0.40-0.63 cm). The mean hypothetical approach angle to the vessel was 22.09 degrees (SD: 4.37 degrees), while the approach angle to the pleura was 39 degrees (SD: 5.31 degrees). No concurrent visualization of the vein and artery was documented in any of the recorded sonoanatomy windows. The tests pointed to an average difference of 0.61 cm in vessel depth in relation to the pleura, and the angle of approach to the vessel was 16.91 degrees smaller when compared with the angle of approach to the pleura ($p < 0.001$).

Conclusions: Using this technique, the supraclavicular approach to the subclavian vein in children is safe and feasible, with an average skin-to-vessel distance of 0.70 cm, minimizing the risk of pleural puncture. Additional studies are required to optimize this technique in the pediatric population.

Keywords: Catheterization, central venous; Ultrasonography; Subclavian vein; Pediatric anesthesia; Anesthesia; Anesthesiology.

Lea la versión en español de este artículo en www.revcolanest.com.co

Resumen

Introducción: Aunque la vena subclavia ofrece ventajas significativas sobre otros abordajes para el acceso venoso central guiado por ultrasonido, no se considera la primera opción en la población pediátrica, principalmente debido a su proximidad con la pleura y la arteria subclavia.

Objetivo: Evaluar las características sonoanatómicas de la vena subclavia y sus estructuras adyacentes utilizando el abordaje supraclavicular en la población pediátrica.

Materiales y métodos: Estudio observacional de corte transversal durante el periodo intraoperatorio, desde junio de 2021 hasta marzo de 2022. Participaron niños ASA I, II y III sometidos a procedimientos quirúrgicos no emergentes bajo anestesia general. Se realizaron las imágenes bajo anestesia general, utilizando un transductor lineal de alta frecuencia para identificar la vena subclavia y medir características anatómicas.

Resultados: Se reclutaron 67 niños, con una mediana de 6 años (RIQ 2-12 años), predominando el sexo masculino (61 %). La mediana de peso fue de 22 kg (RIQ 12,2-34 kg) y la de estatura fue de 115 cm (RIQ 88-142 cm). Las mediciones del vaso mostraron una distancia media de la piel al vaso de 0,70 cm (DE: 0,18 cm) y una de la piel a la pleura de 1,31 cm (DE: 0,28 cm). El diámetro de la vena tuvo una mediana de 0,49 cm (RIQ 0,40-0,63 cm). El ángulo hipotético de aproximación al vaso presentó una media de 22,09 grados (DE: 4,37 grados), mientras que el ángulo de aproximación a la pleura fue de 39 grados (DE: 5,31 grados). No se documentó la visualización simultánea de la arteria y la vena en ninguna de las ventanas sonoanatómicas registradas. Las pruebas indicaron una diferencia promedio de 0,61 cm en la profundidad del vaso respecto a la pleura, y 16,91 grados menos en el ángulo de aproximación al vaso comparado con el ángulo pleural ($p < 0,001$).

Conclusiones: Mediante esta técnica, el abordaje supraclavicular para punción de la vena subclavia en niños es seguro y viable, con una distancia promedio de la piel al vaso de 0,70 cm, minimizando el riesgo de punción pleural. Se requieren estudios adicionales para optimizar esta técnica en la población pediátrica.

Palabras clave: Cateterismo venoso central; Ultrasonografía; Vena subclavia; Anestesia pediátrica; Anestesia; Anestesiología.

INTRODUCTION

Central venous access is often required in perioperative care and is a valuable tool for delivering medications or performing intraoperative monitoring (1). Moreover, it is used long-term to administer antibiotic treatment, parenteral nutrition or chemotherapy (2,3). The short pediatric neck limits maneuverability in ultrasound-guided approaches, while the tendency of the jugular vein to collapse and the proximity to the carotid artery hinder the insertion of a central line through this approach. With the introduction of ultrasound, it is now not only possible to reduce the number of failed cases and complications associated with central line insertion (4), but also to use other approaches with increased safety. The landmark-based supraclavicular approach to the subclavian vein was described by Yoffa in 1965 (5).

Despite notable advantages of the subclavian vein over the jugular and femoral veins because of a lower risk of late complications such as infection and thrombosis, this vessel is not considered a first choice because of its proximity to the pleura and the subclavian artery (6). More than a decade ago, Pirotte and Veyckemans (7) described the possibility of accessing the subclavian vein through the supraclavicular approach with the help of ultrasound. The establishment of the central venous access in order to use the subclavian vein from the supraclavicular approach during the procedure was reviewed in the institution where the study was first conducted (8), with the finding that the technique was safe when ultrasound guidance was used. Prior observations showed that, with the adequate technique, arterial puncture and pneumothorax could be infrequent using this approach. This has been recently ratified in a clinical practice guideline (9) which suggests, with a GRADE 1 recommendation, the use of the subclavian vein in order to prevent central line-associated infection; additionally, the guideline indicates the use of ultrasound to access the brachiocephalic vein through the supraclavicular approach in children as the preferred approach in order to reduce the number of cannulation attempts and mechanical complications (GRADE 2). It is considered to be associated with a high success rate and a low incidence of arterial puncture and pneumothorax.

The objective of this study was to assess the sonoanatomical characteristics of the subclavian vein seen from the supraclavicular approach, seeking to analyze and describe the relationships between the right subclavian vein with the subclavian artery, the pleura and the skin from the supraclavicular fossa, using ultrasound. Additionally, it aims to quantify the superficiality of the subclavian vein from the window used for catheterization through a supraclavicular approach.

METHODS

Observational cross-sectional study in which data were collected during the intraoperative period. The population included ASA I, II and III children taken to non-emergent surgical procedures (NCEPOD 2, 3 or 4 classification) under general anesthesia, with tracheal intubation and with or without neuromuscular blockade at Fundación Hospital de la Misericordia in Bogotá, Colombia, during an 8-month period (June 2021 to March 2022).

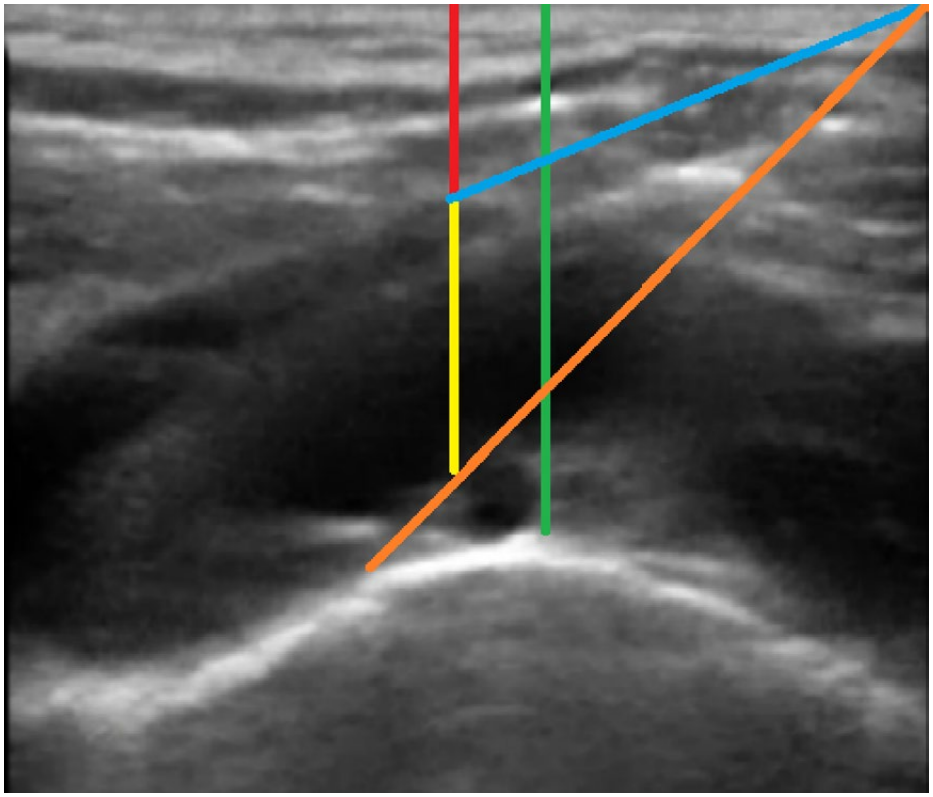
The study was approved by the ethics committee of Fundación Hospital de la Misericordia, under number 342-20R, in May 2021. The informed consent process was carried out with each participant before anesthesia induction and the form was completed and signed by the legal guardian of each individual patient.

The exclusion criteria were patients with syndromes or disease conditions that altered the normal anatomy of the neck, the thorax, or the vascular structures found in those anatomical regions; neonates, premature infants; patients with cervical spine or neck conditions preventing extension; patients with malformation or genetic disease; obese patients; or teenage girls, in case they were pregnant.

The images were acquired by two trained ultrasonographers (Giraldo, DS; Bolívar, MA) with more than four years of experience with central line insertion through the supraclavicular approach in pediatric patients. The patients were divided into the following age groups (10): 1) Infants: less than 2 years of age; 2) pre-schoolers: between 2 and 5 years; 3) Schoolers between 5 and 10 years; 4) Adolescents: over 10 years of age. Age and anthropometric data were obtained from the clinical record.

Under general anesthesia with mechanical ventilation and orotracheal intubation, each patient was positioned in 30 grades Trendelemburg with a roll in the interscapular region to extend the neck and head, which was lateralized 45 grades to the left. Using a hockey stick probe (Sonosite SII, Fujifilm, 6-13 MHz linear HSL25x transducer) the internal jugular vein was followed on the short-axis view to the base of the neck and then the transducer was tilted and the ultrasound plane was taken caudally and anteriorly in order to identify the jugular-subclavian confluence. From the confluence, a long-axis view of the subclavian vein was acquired, trying to leave the pleural dome in the center of the image. The following characteristics were measured after freezing the image (Figure 1).

Figure 1. Sonoanatomical characteristics.



A: Distance from the skin to the most cephalic or superficial portion of the vessel.
B: Vessel diameter measured at level A.
C: Distance from the skin to the pleura in the most cephalic or superficial portion of the latter.
D: Distance from the right upper corner to the most superficial portion of the vessel making the smallest angle possible.
E: Distance from the right upper corner to the most superficial portion of the pleura making the smallest angle possible.

Source: Authors.

Determination of whether the subclavian artery was visualized in the same ultrasound plane was also made. The images were then downloaded to a computer to calculate the following angles using the GeoGebra® software: 1) Minimum approach angle for vessel cannulation, formed by the skin surface and distance line D.; 2) Minimum approach angle for puncturing the pleura, formed by the surface of the skin and distance line E.

A different operator from the one performing the ultrasound scan (Velázquez, DA) used a 5-point Likert scale to rate the quality of the acquired window (11), as follows:

1) Not possible to localize the subclavian vein on the image.
2) The subclavian vein is localized with poor visualization.
3) The subclavian vein is localized with fair visualization.
4) The subclavian vein is localized with good visualization.
5) The subclavian vein is localized with excellent visualization.

STATISTICAL ANALYSIS

Non-probabilistic, consecutive sampling with patient inclusion in accordance with the surgical schedule of the institution. Data for each patient were entered in accordance with the protocol, using Microsoft-Excel 2019. Reported variables were: sex, age (years), weight (kg), height (cm), skin-to-vessel distance, skin-to-pleura distance, angle to the vessel (degrees), angle to the pleura (degrees), image quality (Likert scale), operator name. The STATA 18 software package was used for the statistical analysis of the database.

A descriptive analysis of the study variables was made. Continuous quantitative variables were reported as means and standard deviation (SD) or median and interquartile range (IQR), depending on distribution normality as determined by the Shapiro-Wilk test. On the other hand, categorical variables were reported with relative frequencies (percentages). For exploration purposes, age group differences for each variable were studied (Table 1) by means of hypothesis contrast, using the chi-square tests and Fisher's exact test for comparison of categorical variables, the ANOVA test for quantitative variables of normal distribution, and the Kruskal Wallis test as a non-parametric test for quantitative variables without a normal distribution. Statistical significance of the results was considered to exist with values $p < 0.05$.

RESULTS

Overall, 67 children were recruited during the study. The median age was 6 years (IQR: 2-12 years), with a minimum of 0.08 years and a maximum of 17, predominantly males (61%); median weight was 22 kg (IQR: 12.2-34 kg), and median height 115 cm (IQR: 88-142 cm). The sociodemographic variables and the study measurements are shown in Table 1.

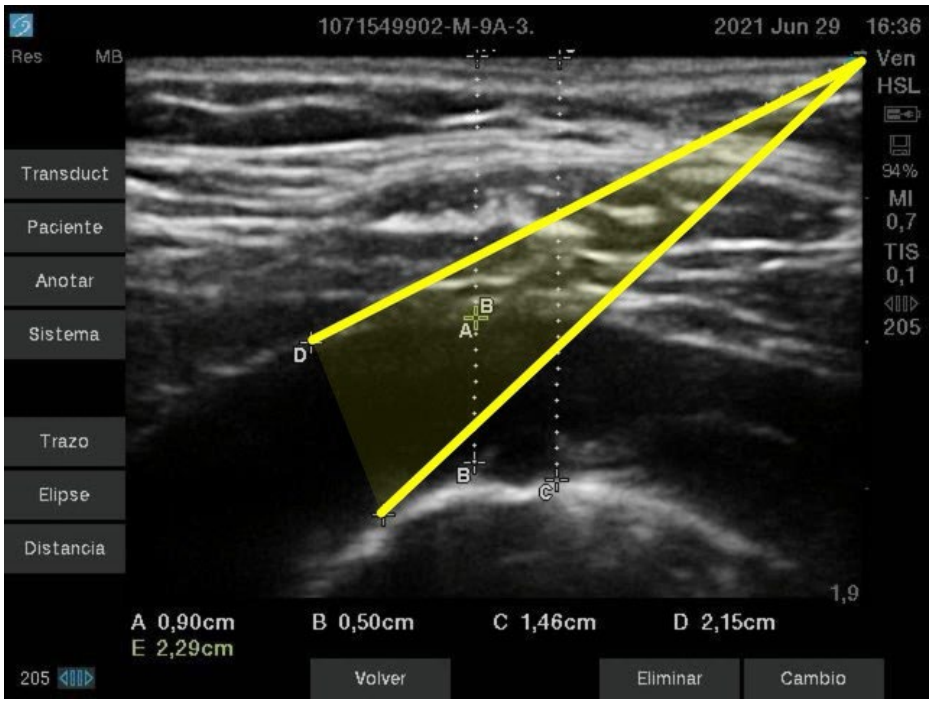
Regarding vessel measurement, the mean skin-to-vessel distance was 0.70 cm

Table 1. Sociodemographic characteristics and variable measurements in all patients and by subgroups.

Variable	Total (n = 67)	Infants (n = 15)	Pre-schoolers (n=15)	Schoolers (n = 18)	Adolescents (n = 19)	P *value*
Sex (n, %)						0.61 [b]
Female	26 (38.81)	5 (33.33)	4 (26.67)	8 (44.44)	9 (47.37)	
Male	41 (61.19)	10 (66.67)	11 (73.33)	10 (55.56)	10 (52.63)	
Median (IQR) age (years)	6.00 (2.00-12.00)	1.3 (0.8-1.7)	3.0 (2.0-4.0)	7.0 (6.0-8.0)	14.0 (13.0-15.0)	<0.001 [b]
Median (IQR) weight (kg)	22.00 (12.20-34.00)	10.0 (7.0-11.8)	13.2 (11.3-16.0)	24.8 (23.0-28.0)	50.0 (43.0-60.0)	<0.001 [b]
Median (IQR) height	115.00 (88.00-142.00)	74.0 (63.0-85.0)	93.0 (89.0-103.0)	122.0 (118.0-126.0)	160.0 (151.0-182.0)	<0.001 [b]
Mean (SD) skin-to-vessel distance (cm)	0.70 (0.18)	0.62 (0.19)	0.63 (0.14)	0.72 (0.16)	0.81 (0.18)	0.006 [c]
Mean (SD) skin-to-pleura distance (cm)	1.31 (0.28)	1.09 (0.19)	1.23 (0.14)	1.23 (0.20)	1.63 (0.21)	<0.001 [c]
Median (IQR) vein diameter (cm)	0.49 (0.40-0.63)	0.40 (0.32-0.47)	0.48 (0.35-0.54)	0.47 (0.40-0.50)	0.70 (0.62-0.78)	<0.001 [b]
Mean (SD) angle (degrees) to vessel	22.09 (4.37)	21.80 (5.67)	20.07 (3.97)	21.67 (3.61)	24.32 (3.40)	0.03 [c]
Mean (SD) angle (degrees) to pleura	39.00 (5.31)	36.80 (4.23)	37.40 (3.68)	36.00 (3.56)	44.84 (3.99)	<0.001 [c]
Image quality Likert scale rating (n. %)						<0.001 [a]
Poor	0 (0.00)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	
Fair	4 (5.97)	4.0 (26.7)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	
Good	51 (76.12)	11.0 (73.3)	14.0 (93.3)	16.0 (88.9)	10.0 (52.6)	
Excellent	12 (17.91)	0.0 (0.0)	1.0 (6.7)	2.0 (11.1)	9.0 (47.4)	
Ultrasonographer (n, %)						0.32 [a]
Bolívar Trujillo	12 (17.91)	2.0 (13.3)	2.0 (13.3)	6.0 (33.3)	2.0 (10.5)	
Giraldo Gutiérrez	55 (82.09)	13.0 (86.7)	13.0 (86.7)	12.0 (66.7)	17.0 (89.5)	

IQR: Inter-quartile range; [a] Fisher's exact test; [b] Kruskal Wallis test; [c] ANOVA.
Source: Authors.

Figure 2. Vascular approach angle.



Safety margin enclosed between the two puncture lines.
Source: Authors.

(SD: 0,18 cm), as compared to the mean skin-to-pleura distance of 1.31 cm (SD: 0.28 cm). Mean vein diameter was 0.49 cm (IQR: 0.40-0.63 cm); and the mean hypothetical approach angle to the vessel was 22.09 degrees (SD: 4.37 degrees), while the mean hypothetical approach angle to the pleura was 39 degrees (SD: 5.31 degrees).

Finally, two ultrasonographers acquired the images, with CG acquiring a higher proportion (82%), with most of them being of good or excellent quality (76% and 18%, respectively). In none of the recorded sonoanatomical windows was simultaneous visualization of the artery and vein documented.

DISCUSSION

This study found that the use of the supraclavicular window to the subclavian vein in the pediatric population allows to find the vessel at a shallow depth (usually less than 10 mm), far from the subclavian artery (which is not visible in the sonoanatomical window), with good or excellent image quality in the vast majority of patients.

Although the subclavian vein is in close relationship with the pleura, it is feasible to perform in-plane cannulation with minimal vascular approach angles of close to 20 degrees, which in most cannulations direct the tip of the needle towards the mediastinum, in a course that avoids the pleural dome (Figure 2). The hypothetical cannulation angle considered in this study assumes that the entry point of the needle is just on the vertex or right upper corner of the ultrasound plane, which does not happen in real life cannulations. Usually, the puncture site moves away from the leading edge of the probe footprint at least a few millimeters, in such a way that a smaller cannulation angle is inevitable when the needle is forced to run more parallel to the skin surface. This has two very important advantages: improved sound reflection results in good needle visualization and allows the puncture to avoid the pleura as the tip of the needle is directed towards the jugular-subclavian confluence. This makes it possible to suggest a potential puncture angle of less than 20 degrees.

For the sake of safety, the aim is to use a 15 degree angle or less in order to visualize the entire length of the needle in the subcutaneous tissue or in the muscle plane bound by the sternal head of the sternocleidomastoid muscle. The minimal depth required for accessing the vessel is then added. According to the authors' experience, this maneuver prevents the puncture from advancing towards the pleura. Moreover, given the small depth at which the vein is found, it is possible to perform the cannulation using a peripheral venous catheter (18-20G in adolescentes and 22G in younger children), thus limiting the reachable depth, as an additional safety factor.

The anatomy of the subclavian vein explains these results. The vein is located posterior to the clavicle and anterior to the scalene attachment on the first rib, arching over the latter at its most cephalad point, and the subclavian vein is separated from the subclavian artery by the anterior scalene muscle (12). This anatomical configuration explains the shallowness of the vein documented in the patients, as well as the absence of the artery in the ultrasound views, considering that the latter is more cephalad and posterior, and is separated from the vein by the anterior scalene muscle.

Studies by other authors show a low risk of pneumothorax and arterial puncture. In a prospective sonoanatomy study, Stachura et al. document improved visualization of the subclavian vein from the supraclavicular fossa when compared to the infraclavicular approach (13). Attof et al. suggest that the supraclavicular approach to the subclavian vein poses a lower risk of failed catheterization, malposition, pneumothorax and arterial puncture when compared with the internal jugular vein and the infraclavicular approach to the

subclavian vein (6). Rhondali et al., in an observational study of 37 children in whom the subclavian vein was cannulated through a supraclavicular approach, reported an 81% success rate on first cannulation and 100% with two attempts, without any major complications. (14) In their study, Byon et al. compared the supraclavicular vs. infraclavicular approach to the subclavian vein in a randomized study of 98 children under three years of age, comparing mean time to catheterization and number of attempts between the supraclavicular and infraclavicular approaches to gain central access to the subclavian vein, with a finding of shorter time and less needle passes when the supraclavicular approach was used (15).

Additionally, the risk of guidewire malposition was lower using the approach from the supraclavicular fossa, showing evidence of greater safety in pediatric patients when the insertion of a central catheter in the subclavian vein is planned using that approach (9,15). In another observational study, Ye et al. described that it is possible to reduce the number of attempts and adverse effects when using a modified formula (based on the insertion point and external landmarks) to estimate the depth of insertion of the subclavian catheter through the supraclavicular approach (16). Finally, in 2016, a prospective study assessed the efficacy of using ultrasound for catheter insertion in children and neonates, and concluded that the procedure was easier and faster in both populations, when this method was used (17).

LIMITATIONS

As far as limitations of this study are concerned, it is important to say that in real-life catheterizations, the angle to approach the vessel can vary, considering that the needle does not always enter the ultrasound plane through the right upper corner. When the needle is first visualized at a greater depth, the real approach angle between the skin and the cannulation site will be smaller than the one reported in this study. Moreover, the sample size was small, making it difficult to extrapolate the data, and consecutive selection can introduce a potential selection bias. Finally, only two operators acquired the images and the majority were acquired by one of them. Given that ultrasound is operator-dependent, image quality will always depend on ultrasonographer skill in achieving optimal visualization.

CONCLUSION

The supraclavicular approach for subclavian vein catheterization in children is a potentially viable and safe technique. The mean skin-to-vessel distance is 0.70 cm, considerably shorter that the skin-to-pleura distance (1.31 cm), suggesting a lower pleural puncture risk. Additionally, ultrasound image quality was good or excellent in 94% of the patients included; and the possibility of cannulating with a minimal approach angle which avoids the pleura along the course of the needle under good needle visualization reduces the risk of puncturing the pleura. Further studies are needed to improve the current central venous access techniques in the pediatric population.

ETHICAL RESPONSIBILITIES

Ethics committee approval

The study was approved by the ethics committee of Fundación Hospital de la Misericordia, under number 342-20R of May, 2021.

Protection of human and animal subjects

The authors declare that no experiments were performed on animals for this study. The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical research ethics committee and with those of the Code of Ethics of the World Medical Association and the Declaration of Helsinki.

Data confidentiality

The authors declare that they have followed the protocols of their work center regarding the publication of patient data.

Right to privacy and informed consent

The authors declare that no patient data appear in this article. The authors obtained an informed consent from the patients and/or subjects referred to in this article, before induction of anesthesia, and all the forms form were signed by the patients' guardians. These documents are kept by the corresponding author.

ACKNOWLEDGEMENTS

Authors' contributions

DSGG: Study conception and planning, research protocol creation, data collection, analysis of the results obtained, drafting, review and approval of the final manuscript.
MABT: Research protocol creation, data collection, analysis of the results obtained, drafting, review and approval of the final manuscript.
DAVG: Research protocol creation, data collection, analysis of the results obtained.
JACR: Analysis of the results obtained, drafting and review of the final manuscript.

Assistance for the study

None declared.

Financial support and sponsorship

No specific funding was received for the study from public sector agencies, the business sector, or non-profit organizations.

Conflicts of interest

The authors declare not having disclosures to make.

Presentations

None declared.

Appreciation

None declared.

REFERENCES

1. Merchaoui Z, Lausten-Thomsen U, Pierre F, ben Laiba M, le Saché N, Tissieres P. Supraclavicular approach to ultrasound-guided brachiocephalic vein cannulation in children and neonates. Front Pediatr. 2017;5:1-18. https://doi.org/10.3389/fped.2017.00211

2. Balaban O, Aydin T. Case report ultrasound-guided subclavian vein cannulation in neonate via supraclavicular approach. Case Rep Anesthesiol. 2017; 2017: 9789427. https://doi.org/10.1155/2017/9789427

3. Klug W, Triffterer L, Keplinger M, Seemann R, Marhofer P. Supraclavicular ultrasound-guided catheterization of the brachiocephalic vein in infants and children: A retrospective analysis. Saudi J Anaesthesia. 2016;10:143-8. https://doi.org/10.4103/1658-354X.168802

4. Shime N, Hosokawa K, MacLaren G. Ultrasound imaging reduces failure rates of percutaneous central venous catheterization in children. Pediatr Crit Care Med. 2015;16(8):718-25. https://doi.org/10.1097/PCC.0000000000000470

5. Yoffa MB. Supraclavicular subclavian veni-puncture and catheterization. The Lancet. 1965;2:614-7. https://doi.org/10.1016/S0140-6736(65)90519-2

6. Attof R, Rhondali O, Combet S, Chassard D, de Queiroz M. [Ultrasound-guided supraclavicular subclavian vein catheterization: a novel approach in children]. Ann Fr Anesth Reanim. 2010;29(9):651-4. https://doi.org/10.1016/j.annfar.2010.05.036

7. Pirotte T, Veyckemans F. Ultrasound-guided subclavian vein cannulation in infants and children: a novel approach. Br J Anaesth. 2007;98(4):509-14. https://doi.org/10.1093/bja/aem041

8. Giraldo Gutiérrez DS, Bautista Sánchez J, Reyes Patiño RD. Supraclavicular approach for subclavian vein catheterization in pediatric anesthesia: The reborn of an ancient technique with the ultrasound's assistance. Rev Esp Anestesiol Reanim. 2019;66(5):267-76. https://doi.org/10.1016/j.redar.2019.01.001

9. Timsit JF, Baleine J, Bernard L, Calvino-Gunther S, Darmon M, Dellamonica J, et al. Expert consensus-based clinical practice guidelines management of intravascular catheters in the intensive care unit. Ann Intensive Care. 2020;10(1):118. https://doi.org/10.1186/s13613-020-00713-4

10. Williams K, Thomson D, Seto I, Contopoulos-Ioannidis DG, Ioannidis JP, Curtis S, et al. Standard 6: age groups for pediatric trials. Pediatrics. 2012;129(Suppl 3):S153-60. https://doi.org/10.1542/peds.2012-0055l

11. Joshi A, Kale S, Chandel S, Pal DK. Likert Scale: explored and explained. Curr J Appl Sci Technol. 2015;7(4): 396-403. https://doi.org/10.9734/BJAST/2015/14975

12. Teman N, Hobson C, Tribble R, Tribble C. The venerable subclavian line. Heart Surg Forum. 2021;24(5):E925-34. https://doi.org/10.1532/hsf.4383

13. Stachura MR, Socransky SJ, Wiss R, Betz M. A comparison of the supraclavicular and infraclavicular views for imaging the subclavian vein with ultrasound. Am J Emerg Med. 2014;32(8):905-8. https://doi.org/10.1016/j.ajem.2014.05.001

14. Rhondali O, Attof R, Combet S, Chassard D, de Queiroz Siqueira M. Ultrasound-guided subclavian vein cannulation in infants: supraclavicular approach. Paediatr Anaesth. 2011;21(11):1136-41. https://doi.org/10.1111/j.1460-9592.2011.03614.x

15. Byon HJ, Lee GW, Lee JH, Park YH, Kim HS, Kim CS, et al. Comparison between ultrasound-guided supraclavicular and infraclavicular approaches for subclavian venous catheterization in children - A randomized trial. Br J Anaesth. 2013;111(5):788-92. https://doi.org/10.1093/bja/aet202

16. Ye P, Tan Y, Shi S, Liu L. Optimal insertion depth of subclavian vein catheterization via the right supraclavicular approach in children. Paediatr Anaesth. 2021;31(3):346-51. https://doi.org/10.1111/pan.14107

17. Nardi N, Wodey E, Laviolle B, De La Brière F, Delahaye S, Engrand C, et al. Effectiveness and complications of ultrasound-guided subclavian vein cannulation in children and neonates. Anaesth Crit Care Pain Med. 2016;35(3):209-13. https://doi.org/10.1016/j.accpm.2015.09.007