Review Article

Role of ultrasound-guided brachiocephalic venous cannulation for difficult venous cannulation in pediatric patients: A narrative review

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Abstract

Difficult venous access is characterized by non-visible and non-palpable veins; a highly experienced operator is required with the use of technological aids to insert a vascular device. Patients with difficult venous cannulation undergo multiple, painful attempts to gain peripheral venous access. Compared to adults, inserting a central venous cannulation (CVC) is thought to be a more difficult procedure in children, particularly in neonates and young infants. IJV catheterization is perceived as the gold-standard route for CVC but remains difficult for newborn, premature, and critically ill children. Therefore, in recent years, novel ultrasound-guided brachiocephalic venous (BCV) cannulation in neonates has gained popularity. The aim of this narrative review was to assess the success rate. The primary objective of this review was to determine the first-attempt success rate. The secondary objectives were the total number of attempts, cannulation time, overall success rate, and complications. All articles relevant to BCV cannulation were searched in six major databases (PubMed, Embase, Medline, Ovid, PMC, and Google Scholar). A total of 16 records were included in this narrative review. According to Breschan *et al*., Merchaoui *et al*., and Vafek *et al*., the success rate of BCV cannulation in children was 89.1%, 98.4%, and 50%, respectively. Kumar *et al*., Erroz *et al*., and Breschan *et al*. found that the first-attempt success rate was higher in the in-plane left BCV (74%, 73% and 82.9% respectively). Falay *et al*. and Erroz *et al*. found a lower complication and infection with BCV cannulation. There is evidence that during CVC placement, US-guided BCV cannulation has a higher first-attempt success rate, requires less cannulation time, and has a lower complication rate in comparison to other approaches.

Keywords: Brachiocephalic venous cannulation, pediatric patients, ultrasound

Introduction

Difficult venous access is characterized by non-visible and non-palpable veins; a highly experienced operator is required with the use of technological aids to insert a vascular device.[1] Patients with difficult venous cannulation undergo multiple, painful attempts to gain peripheral venous access. For children, the insertion of a central venous catheter (CVC) must be done safely and effectively. Although the landmark technique has been used for cannulation over time, adults and children now receive standard care when employing ultrasonography (US) guidance.[2-4] US guidance decreases the number of puncture attempts and enhances cannulation success rates when compared with landmark techniques.[2-4] Compared to adults, inserting a CVC is thought to be a more difficult procedure in children, particularly in neonates and young infants. In these situations, the vein is tiny, the puncture region is constrained, and anatomical references are difficult to establish. Consequently, 4%–38%

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of cannulation attempts fail when employing the landmark technique.[5] The internal jugular vein (IJV), subclavian vein (SCV), or femoral vein are the most commonly used for CVC insertion routes.[6,7] IJV catheterization is perceived as the gold-standard route for CVC but remains difficult for newborn, premature, and critically ill children. Therefore, in recent years, novel US-guided BCV cannulation in neonates has regained popularity.[8] Breschan *et al.*[8] recently provided a detailed description of a novel US-guided left brachiocephalic vein (BCV) cannulation. They found that BCV is substantially larger than IJV. They recommended US-guided left BCV cannulation in small infants as it is convenient and effective. Left BCV (LBCV) cannulation is easier in pediatric patients because of its superficial location and greater diameter.[9] This method is especially helpful for patients with a history of multiple cannulations, patients whose IJV vessel lumen is small (e.g., volume-deficient patient), and patients for whom subclavian puncture is contraindicated (e.g., patients with compromised lung functions, infection at the site).[10,11] The aim of this narrative review was to assess the success rate. The primary objective of this review was to determine the first-attempt success rate. The secondary objectives were the total number of attempts, cannulation time, overall success rate, and complications.

Material and Methods

This narrative review was written as a scale for the quality assessment of narrative review articles (SANRa). All articles relevant to BCV were searched in six major databases (PubMed, Embase, Medline, Ovid, PMC, and Google Scholar) from October 22 to October 26, 2023. A total of 14,000 records were identified; 13,983 were excluded because they were not relevant to the study design. A total of 16 records were included in this narrative review [Figure 1]. The PICO (populations of interest, intervention, comparator, and outcomes) model for this narrative review was as follows: population: 1. ASA I/II/III; 2. Age (either sex): 0–15 years; 3. Intervention: scheduled for BCV cannulation. Exclusion criteria: 1. Duplicate or irrelevant article; 2. Non-English article keywords used to search the articles included in this narrative review were "brachiocephalic venous cannulation," "ultrasound," and "pediatric patients." The types of articles included in this narrative review were case reports, randomized clinical trials, and reviews.

Outcome measure for rating success for BCV cannulation

Anatomy of brachiocephalic vein: BCVs are also called innominate veins. BCVs are formed by the confluence of the SCV and IJV on the right and left, respectively.[12] Both the BCVs and the vena cava are valveless. Due to the anatomic position of the superior vena cava on the right of the middle mediastinum, the left BCV has an oblique course and is longer than the right. The right BCV measures typically 2–3 cm, while the left measures approximately 6 cm.

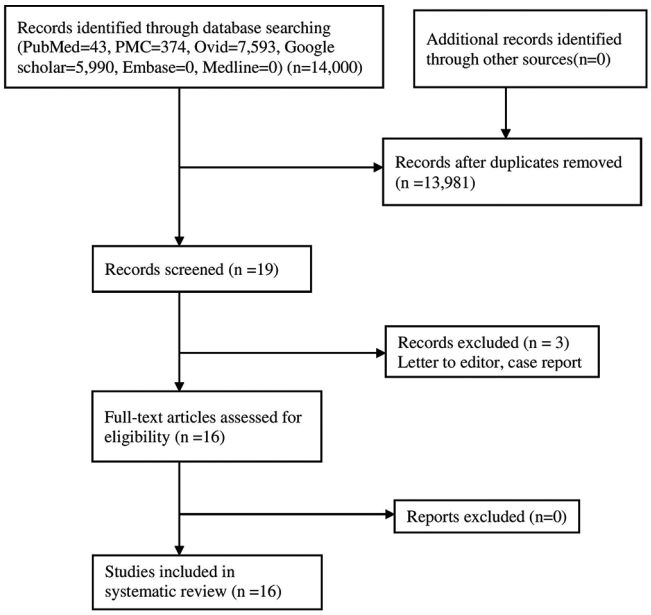

Figure 1: Flow diagram of study methodology

Techniques of BCV cannulation

In BCV cannulation, the patient's position is supine with a shoulder roll and head turned on the contralateral side. BCV insertion is done by the Seldinger method. In the in-plane technique, the linear USG probe is placed in the supraclavicular fossa parallel to the medial end of the clavicle. The probe is tilted caudally to obtain an in-plane view of BCV and the venous confluence of three vessels (BCV, IJV, and SCV). Doppler power is used to differentiate subclavian and other arteries from veins. The needle is inserted in-plane to probe from the lateral to the medial direction to puncture BCV [Figure 2]. Out-plane technique: The linear US probe is positioned longitudinally (long-axis view) over the inferior area of the IJV, maintaining the caudal end of the transducer overlaying the clavicle. The Pirogoff venous confluence is seen in [Figure 3]. Venous and arterial structures are distinguished using color Doppler US. The needle punctures the left BCV medially and caudally, lateral to the US transducer. Kumar *et al.*[13] compared the two techniques (in-plane vs. out-plane) for left BCV cannulation in the pediatric population.

Right versus left BCV cannulation

Both sides are attainable, and there is not enough evidence in the literature to consistently favor one over the other. Table 1 summarizes the cases, of which 52% were placed in the right SCV and 48% in the left SCV.[14-20] According to Breschan *et al.*,[8] the right BCV is often shorter than the

left BCV. Furthermore, the left BCV runs in a much more horizontal path, whereas the right BCV immediately makes an acutely angled caudal turn. Longitudinal US imaging is more challenging in the right BCV due to its shorter length and sharper angle. The right side of the in-plane technique of needle advancement is thought to be more challenging. This may be of greater importance in neonates, especially as the left BCV is larger than the right in preterm babies.[21] The oblique course of the left BCV provides whole needle path visibility during cannulation, thus preventing complications.

Clinical reports

Few studies have compared BCV cannulation with internal jugular venous cannulation, infraclavicular subclavian venous cannulation, femoral venous cannulation, and right BCV cannulation versus left BCV cannulation [Table 2]. Thompson *et al.*[10] studied US-guided BCV cannulation in infants and children (49 patients). Duration of insertion and characterization of venous access at removal were the primary outcomes. They found that BCV lines were retained postoperatively for an average of 7 days, and three patients had problems: two had trouble threading the wire, and one had an artery puncture. By going to the contralateral side of the approach, all three were successfully managed. Falay *et al.*[22] compared US-guided left BCV versus right IJV cannulation. Their primary outcome was the frequency of complications in CVC installations via RIJV versus LBCV in cardiac surgery patients. The complication rate of chylothorax was in the LBCV group (7.7%) and RIJV group (8.6%), thrombosis in LBCV (5.6%) and RIJV group (4.5%). They suggest that the left BCV approach is a safe substitute for the IJV. Breschan *et al.*[23] evaluated the clinical feasibility of supraclavicular US-guided cannulation of the BCV in newborns weighing less than 1500 g. They found that lower-weight babies did not require significantly more cannulation attempts; the success rate was 89.1%. Kumar *et al.*[13] compared in-plane versus out-of-plane techniques of BCV cannulation in pediatric patients. Their primary outcome was the first-attempt success rate. They found that the first-attempt success rate was higher in the in-plane left BCV (74%) than in the out-of-plane left BCV (36%). The rate of unsuccessful BCV cannulation (12%) and hematoma development (12%) was significantly higher in the out-of-plane technique in comparison to the in-plane technique (2%). Erroz *et al.*[24] assessed the risk of central line-associated bloodstream infection (CLABSI) of US-guided cannulation of the BCV compared to standard epicutaneous cava catheters (ECCs) in preterm infants. The primary outcome was the CLABSI rate per 1000 days of catheter use. They found lower CLABSI in BCV cannulation in comparison to ECCs. Breschan *et al.*[8] performed retrospective analysis, and their primary objective was to evaluate the clinical effectiveness and safety of US-guided supraclavicular

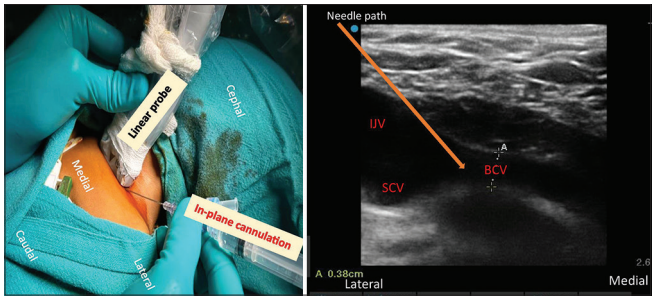

Figure 2: Needle probe position and sonoanatomy of the in-plane approach of BCV cannulation

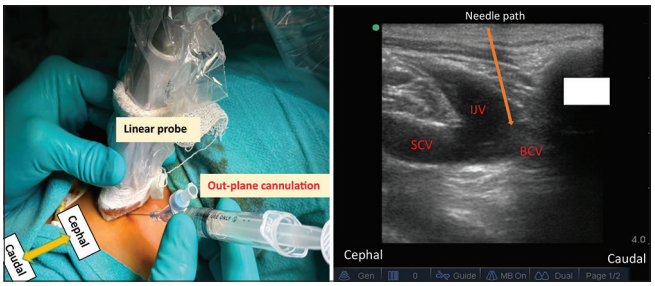

Figure 3: Needle probe position and sonoanatomy of the out-plane approach of BCV cannulation

Table 1: Comparative feature of right versus left BCV cannulation

Reference	Patients (*n*)	Weight (kg) range median	Right- vs. left-sided catheter	Results	Complications
Pirotte *et al.*[14]	23	2.2–27.0 (6.1)	67% left-sided 33% right-sided	Success rate: 100% First-attempt success rate: 84%	No Major complications
Kulkarni *et al.*[15]	150	2.7–35 (median not reported)	6.5% left-sided 93.5% right-sided	Success rate: 98.77 First-attempt success rate not reported	1.33 (2) arterial puncture 0.65% (1) pneumothorax
Breschan *et al.*[16]	136	0.7–10 (3.7)	92.9% left-sided 7.1% right-sided	Success rate: 98.9% First-attempt success rate: 82.9%	No major complications
Rhondali *et al.*[17]	37	4.1 (range not reported	73% left-sided 27% right-sided	Success rate: 100% First-attempt success rate: 81%	No major complications
Guilbert *et al.*[18]	42	2–70 (6.5)	Not specified	Success rate: 97.6% First-attempt success rate not reported	1 arterial puncture, 1 pneumothorax
Byon *et al.*[19]	49	2.6–17.0 (8.1)	Not specified	Success rate: 100% First-attempt success rate: 93.9%	No major complication
Park *et al.*[20]	11	2.6–12.4 (4.0)	36% left-sided 64% right-sided	Success rate: 100%	No major complication

Table 2: Evidence summary of brachiocephalic venous (BCV) cannulation

Study	Intervention control	No. of patients	Age (Median)/ wt (kg)	Primary outcome	Outcome
Thompson[10]	Left BCV Right BCV	32 19	3.8 years (1 month to 16 years)/1.4–88	Duration of insertion And characterization of venous access at removal	USG supraclavicular in-plane cannulation of BCV is useful, durable, and has less complication in children.
Falay *et al.*[22]	Left BCV Right IJV	143 337	5 months (0.05, 11)/5.5 (4.13, 8.2) 10.5 months [4.0, 43.0]/8.39 [5.05, 15.3]	Frequency of complications in CVC installations via RIJV versus LBCV	The approach via the left BCV is a safe alternative to the internal jugular vein. In a direct comparison of the two approaches, we found no significant differences regarding complications in our population of children undergoing pediatric cardiac surgery.
Breschan *et al.*[23]	Left BCV	46	Infant/1.2	Success rate First attempt	89.1% 80%
Kumar *et al.*[13]	In-plane left BCV Out-plane left BCV	50 50	118 113/5.5 _ 3.0 158 _ 124/5.8 _ 2.3	First attempt success rate	The first-attempt success rate was higher in In plane left BCV (74%) than in out-plane left BCV (36%)
Erroz *et al.*[24]	BCV ECC	21 75	Preterm infant	CLABSI rate per 1000 days of catheter use	Lower rate of CLABSI when US-guided supraclavicular BCV catheters were used compared to standard ECCs in preterm infants.
Breschan *et al.*[8]	Left BCV Right BCV	67 75	Preterm infant (median not reported)/2.1	evaluate the clinical effectiveness and safety of US-guided supraclavicular BCV cannulations in low-birth-weight newborns	Success rate was 94% One-attempt success rate: 70%
Vafek *et al.*[25]	Landmark Us-guided	55 51	Pediatric patients up to 19 years.	Overall success rate and the first attempt success rate US-guided CVC insertion and in the landmark CVC insertion in pediatric patients.	Higher overall success rate and the first success rate in the US-guided CVC insertion group. Left BCV vein, cannulated in 50.0% of patients.
Breschan *et al.*[26]	Right BCV Grade I view Grade II	 45 29	Infant (median not reported)/3.4	number of needed cannulation attempts by placing a linear US probe in the right supraclavicular region and using a strict in-plane cannulation technique in small infants	1st attempt cannulation in grade I: 90% 1st attempt cannulation in grade II: 41.4%
Avanzini *et al.*[27]	Right vs. left BCV	95 4.2:1	41 months	Not reported	USG SC cannulation of the BCV represents a safe and alternative approach for CVC placement in children
Klug *et al.*[28]	Left BCV Right BCV Right IJV Left IJV	86 10 6 1	2.74 years/12.95	Compared US-guided cannulation of the BCV with other puncture sites (success rates, complications).	The cannulation of the left BCV proved to be an eligible alternative in comparison to other puncture sites. Use of the left BCV was associated with fewer side effects.
Nardo *et al.*[29]	Left BCV	34	12.5 months/9.25 kg	To evaluate the safety and effectiveness of US-guided left BCV cannulation in infants and children with underlying bleeding conditions	Retrospective study confirming the safety and effectiveness of US-guided left BCV catheterization in infants and children with underlying bleeding disorders.
Erroz *et al.*[30]	BCV IJV	22 24	13 months/9.5	First-attempt success rate BCV versus IJV	73% vs. 37.5%
Aytekin *et al.*[31]	Left BCV Right BCV	23 11	80.8 days/3.48	Technical success rate	Technical success rate 97%
Erroz *et al.*[32]	Left BCV Right BCV	32 8	13 days/<1.8	First attempt success rate	First-attempt success rate was 72.5%
Merchaoui *et al.*[33]	BCV	1250	Children and neonates	success rate	success rate: 98.4%
Abdelmaboud[34]	Right BCV Right IJV	40 40	2±1.6/16±9 2±1.4/17±8	To evaluate which is easier, US-guided BCV cannulation or IJV cannulation	US-guided supraclavicular BCV cannulation was easier with higher success rate and shorter cannulation time with less complications compared with US-guided IJV cannulation

BCV cannulations in low-birth-weight newborns. They found that the success rate was 94%; the one-attempt success rate was 70%, and 1% inadvertent arterial puncture was noted. US-guided cannulation of the BCV seems to be a convenient, effective, and, more importantly, safe method to insert central venous catheters (CVCs) in preterm infants. The left BCV is easier to cannulate in comparison to the right BCV. Breschan *et al.*[25] studied the sonographic view of right BCV, and the primary outcome was the number of needed cannulations attempted by placing a linear US probe in the right supraclavicular region and using a strict in-plane cannulation technique in small infants. They found that the ease of the supraclavicular cannulation of the right BCV in small infants correlated significantly with the optimum sonographic view. In Vafek *et al.*'s analysis of BCV cannulation in children, they found a 50% success rate in left BCV.[26] Avanzini *et al.*[27] studied percutaneous USG CVC positioning in the BCV; devices inserted during this period were open-ended, either single or double-lumen tunneled CVC. The series was divided into three consecutive study periods to determine the relative incidence of repositioning and complications. BCV represents a safe approach for central line placement in children. It proved to be versatile as it can be used in premature infants as well as in adolescents. Klug *et al.*[28] compared US-guided cannulation of the BCV with IJV and femoral vein about the success rates and complications). Left BCV group CVC cannulation was successful in 89.5% They found that the cannulation of the left BCV proved to be a feasible alternative in comparison to other puncture sites. Nardo *et al.*[29] studied BCV cannulation in infants and children with bleeding disorders. They confirmed the safety and effectiveness of US-guided left BCV catheterization in infants and children with underlying bleeding disorders. US-guided LBCV cannulations are a valid, safe, and effective alternative to US-guided cannulation of the IJV and femoral vein. Erroz *et al.*[30] compared US-guided in-plane supraclavicular cannulation of the BCV to improve cannulation success rates compared to transverse out-of-plane IJV cannulation in critically ill patients (24 IJV and 22 BCV). They found that the first-attempt success rate was higher in the BCV than in the IJV group (73% vs. 37.5%). The median (range) number of cannulation attempts [1 (1–3) vs. 2 (1–4)] and cannulation time [66 (25–300) vs. 170 (40–500) seconds] were significantly lower in the BCV group. Overall procedure success was higher for the BCV (95% vs. 83%). Aytekin *et al.*[31] presented their own experience with US-guided supraclavicular BCV catheterization in infants weighing less than 5 kg. They found that the US-guided supraclavicular BCV approach is a preferable option for CVC in small infants with respect to high success and low complication rates. Erroz *et al.*[32] investigated the first-attempt and overall success rate in BCV cannulation. They found that BCV cannulation in children's first attempt and overall success occurred at 72.5% and 95%, respectively. Left BCV was more commonly chosen for cannulation (32/40: 80%), with a higher first-attempt success rate of 24/32 (75%) compared with right BCV (5/8; 62.5%). The catheter-associated infection rate was 2.4/1000 catheter days. Merchaoui *et al.*[33] reviewed BCV cannulation and compared it with other techniques of CVC cannulation. They found that the success rate was 98.4%, and the technique offers a safe and practical alternative to cannulation of IJV and FV in children and neonates. Importantly, this technique has been reported to be feasible even for children weighing less than 1000 g. Abdelmaboud MA. compared US-guided BCV cannulation with IJV cannulation and found that US-guided supraclavicular BCV cannulation is simpler with a higher success rate and a shorter cannulation time with fewer complications in comparison to US-guided IJV cannulation.[34]

Future Investigations and Clinical Indications: Several studies have revealed that US-guided in-plane BCV cannulation has a higher success rate, shorter cannulation time, and a lower rate of complications in comparison to IJV, SCV, and fetal vein cannulation in critically ill, preterm, and low-birth-weight babies. Many studies said that left BCV cannulation is easier than right BCV. This is because of the more horizontal course of the left BCV. Most studies are retrospective; there are very few prospective randomized control trials established for BCV cannulation in neonates and pediatric age groups. Many more randomized control trials are needed to establish the role of left BCV cannulation in situations of difficult cannulation in the pediatric population.

Clinical application

1. Useful in preterm neonates, preterm, critically ill patients, and patients with coagulation disorders
2. Patients whose IJV vessel lumen is small (e.g., volume-deficient patients) and patients for whom subclavian puncture is contraindicated
3. BCV permits the placement of relatively large bore CVC in very small infants.

Conclusion

There is evidence that during CVC placement, US-guided BCV cannulation has a higher first-attempt success rate, requires lesser cannulation time, and has a lower complication rate in comparison to other approaches. The supraclavicular approach to left BCV cannulation provides an alternative option for CVC placement in situations of difficult cannulation in premature and low-birth-weight babies.

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Conflicts of interest

Nil

References

1. Sebbane M, Claret P-G, Lefebvre S, Mercier G, Rubenovitch J, Jreige R, *et al*. Predicting peripheral venous access difficulty in the emergency department using body mass index and a clinical evaluation of venous accessibility. J Emerg Med 2013;44:299–305.
2. Troianos CA, Hartman GS, Glas KE, Skubas NJ, Eberhardt RT, Walker JD, *et al*. Guidelines for performing ultrasound guided vascular cannulation: Recommendations of the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists. J Am Soc Echocardiogr 2011;24:1291–318.
3. Lamperti M, Bodenham AR, Pittiruti M, Blaivas M, Augoustides JG, Elbarbary M, *et al*. International evidence-based recommendations on ultrasound-guided vascular access. Intensive Care Med 2012;38:1105–17.
4. Jöhr M, Berger TM. Venous access in children: State of the art. Curr Opin Anaesthesiol 2015;28:314–20.
5. Shime N, Hosokawa K, MacLaren G. Ultrasound imaging reduces failure rates of percutaneous central venous catheterization in children. Pediatr Crit Care Med 2015;16:718–25.
6. Camkiran Firat A, Zeyneloglu P, Ozkan M, Pirat A. A randomized controlled comparison of the internal jugular vein and the subclavian vein as access sites for central venous catheterization in pediatric cardiac surgery. Pediatr Crit Care Med 2016;17:413-9.
7. Silvetti S, Aloisio T, Cazzaniga A, Ranucci M. Jugular vs femoral vein for central venous catheterization in pediatric cardiac surgery (PRECiSE): Study protocol for a randomized controlled trial. Trials 2018;19:329.
8. Breschan C, Graf G, Jost R, Stettner H, Feigl G, Neuwersch S, *et al*. A retrospective analysis of the clinical effectiveness of supraclavicular, ultrasound-guided brachiocephalic vein cannulations in preterm infants. Anesthesiology 2018;128:38-43.
9. Breschan C, Platzer M, Jost R, Stettner H, Beyer AS, Feigl G, *et al*. Consecutive, prospective case series of a new method for ultrasound-guided supraclavicular approach to the brachiocephalic vein in children. Br J Anaesth 2011;106:732-7.
10. Thompson ME. Ultrasound-guided cannulation of the brachiocephalic vein in infants and children is useful and stable. Turk J Anaesthesiol Reanim 2017;45:153-7.
11. Saini V, Sardana DK, Samra T, Sethi S. Trouble shooting a small sized IJV. Indian J Crit Care Med 2017;21:335-6.
12. Woodhouse P, Waheed A, Bordoni B. Anatomy thorax, Brachiocephalic (innominate) veins statpearls (internate). 2022 Sep 26 In: Statpearls (internate). Treasure Island (FL): StatPearls Piblishing; 2024 jan-PMID: 31335059.
13. Kumar A, Sinha C, Kumar A, Kumari P, Singh K, Sinha AK. Comparison between in-plane and out-of-plane techniques for ultrasound guided cannulation of the left brachiocephalic vein in pediatric population: A randomised controlled trial. Anaesth Crit Care Pain Med 2023;42:101247.
14. Pirotte T, Veyckemans F. Ultrasound-guided subclavian vein cannulation in infants and children a novel approach Br J Anaesth 2007;98:509-14.
15. Kulkarni V, Mulavisala KP, Mudunuri RK, Byalal JR Ultrasound-guided supraclavicular approach to the subclavian vein in infants and children Br J Anaesth 2012;108:162.
16. Breschan C, Platzer M, Jost R, Stettner H, Feigl G, Likar R. Ultrasound- guided supraclavicular cannulation of the brachiocephalic vein in infants. A retrospective analysis of a case series. Paediatr Anaesth 2012;22:1062–7.
17. Rhondali O, Attof R, Combet S, Chassard D, de Queiroz Sigueira M. Ultrasound- guided subclavian vein cannulation in infants: Supraclavicular approach. Paediatr Anaesth 2011;21:1136-41.
18. Guilbert A-S, Xavier L, Ammouche C, Desprez P, Astruc D, Diemunch P, *et al*. Supraclavicular ultrasound-guided catheterization of the subclavian vein in pediatric and neonatal ICUs: A feasibility study. Pediatr Crit Care Med 2013;14:351-5.
19. 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;111:178-92.
20. Park Y, Lee J, Byon H, Kim H, Kim J. Transthoracic echocardiographic guidance for obtaining an optimal insertion length of internal jugular venous catheters in infants. Paediatr Anaesth 2014;24:927–32.
21. Eifinger F, Briskn B, Roth B, Koebke J. Topographical anatomy of the central venous system in extremely low-birth weight neonates less than 1000 grams and the effect of central venous catheter placement. Clin Anat 2011;24:711-6.
22. Falay D, Schindler E, Mikus M, Asfour B, Schroth S, Schenk A, Baehner T. Ultrasound guided supraclavicular cannulation of left brachiocephalic versus right internal jugular vein: Comparative analysis of central venous catheter -associated complications. Pediatr Anesth 2023;33:219–28.
23. Breschan C, Graf G, Arneitz C, Stettner H, Feigl G, Neuwersch S, *et al*. Feasibility of the ultrasound-guided supraclavicular cannulation of the brachiocephalic vein in very small weight infants: A case series. Paediatr Anaesth 2020;30:928-33.
24. Erroz IO, Garacia AF, Juan BA, Seara ST, Quintela PA, Nunez AR, *et al*. Ultrasound-guided supraclavicular cannulation of the brachiocephalic vein may reduce central line–associated bloodstream infection in preterm infants. Eur J Pediatr 2020;179:1655–63.
25. Vafek V, Skríšovská T, Kosinová M, Klabusayová E, Musilová T, Kramplová T, *et al*. Central venous catheter cannulation in pediatric anesthesia and intensive care: A prospective observational trial. Children 2022;9:1611.
26. Breschan C, Graf G, Jost R, Stettner H, Feigl G, Goessler A, *et al*. Ultrasound-guided supraclavicular cannulation of the right brachiocephalic vein in small infants: A consecutive, prospective case series. Paediatr Anaesth 2015;25:943-9.
27. Avanzini S, Mameli L, Disma N, Zanaboni C, Dato A, Montobbio G. Brachiocephalic vein for percutaneous ultrasound-guided central line positioning in children: A 20-month preliminary experience with 109 procedures. Pediatr Blood Cancer 2017;64:330–35.
28. 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 Anaesth 2016;10:143-8.
29. Nardo MD, Stoppa F, Marano M, Ricci Z, Barbieri MA, Cecchetti C. Ultrasound–guided left brachiocephalic vein cannulation in children with underlying bleeding disorders: A retrospective analysis. Pediatr Crit Care Med 2014;15:44–8.
30. Erroz IO, Lozon AM, Quintela PA, Nunez AR. Comparison of ultrasound guided brachiocephalic and internal jugular vein cannulation in critically ill children. J Crit Care 2016;35:133–7.
31. Aytekin C, Ozyer U Harman A, Boyvat F. Ultrasound-guided brachiocephalic vein catheterization in infants weighing less than five kilograms. J Vasc Access 2015;16:512-4.
32. Erroz IO, Quintela PA, Seara ST, Gonzalez AJ, -Blanco SR, Martinez JLV. Ultrasound-guided cannulation of the brachiocephalic vein in neonates and preterm infants: A prospective observational study. Am J Perinatol 2018;35:503–8.
33. Merchaoui Z, Thomsen UL, Pierre F, Laiba MB, sache NW, Tissieres P. Supraclavicular approach to ultrasound-guided brachiocephalic vein cannulation in children and neonates. Front Pediatr 2017;5:211.
34. Abdelmaboud MA. Ultrasound-guided supraclavicular brachiocephalic vein cannulation versus internal jugular vein cannulation in young children. Res Opin Anesth Intensive Care 2019;6:455–60.