Original Article

The Study of the Feasibility of Ultrasound-guided Catheterization of the Right Brachiocephalic Vein in Adult Patients: A Prospective Observational Study

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Abstract

Background: The brachiocephalic vein (BCV) is a feasible option for central venous access in the pediatric population and is rapidly developing as an alternative site for insertion of the central line in young children with faster insertion times, fewer attempts, and lower rates of complications. However, studies demonstrating the feasibility of BCV catheterization in adult patients are insufficient. The current study sought to assess the safety and effectiveness of ultrasound-guided supraclavicular right BCV cannulations in adults. **Methods:** A linear array Ultrasound (US) probe was used to obtain a longitudinal picture of the BCV beginning at the junction of the internal jugular vein and the subclavian vein in the supraclavicular region. Under US supervision, the needle was guided into the BCV using the in-plane approach. A prospective study was performed on 80 adult patients scheduled for elective and emergency operative procedures under general anesthesia requiring a central venous catheter (CVC). Success rates and complications that occurred during catheter insertion were analyzed. **Results:** CVC placement was successful in all adults. The procedure was successful at the first attempt in 74 cases (92.5%) and after 2 attempts in six patients (7.5%). The time to guide wire insertion was 31.26 s (19–58 s), and catheter insertion took 88.44 s (63–145 s). The mean length of catheter insertion was 10.46 cm. No complications were noted. **Conclusion:** Ultrasound-guided supraclavicular BCV catheterization offers a new and safe method for central venous line catheterization in adults. However, larger trials and meta-analyses are needed to confirm these findings and evaluate the safety of this technique.

Keywords: Brachio-cephalic vein, central venous access, supraclavicular approach, ultrasound

Introduction

Central venous catheterization is an essential component of critical care and resuscitation and enables the delivery of fluids, medications, and blood products to critically ill patients. The use of central venous catheters (CVCs) is associated with improved patient outcomes, such as reduced morbidity as well as mortality rates.[1]

In adult patients, the internal jugular vein (IJV) is the most frequently used site for central venous catheterization,[2,3] while the brachiocephalic vein (BCV) is commonly used in pediatric patients.[4-6] However, the use of BCV for central venous catheterization in adults is limited, and few studies have compared it with other cannulation sites.[7]

A feasibility study would provide valuable insight into the safety and efficacy of this technique in this patient population. This study aimed to evaluate the feasibility of BCV cannulation in adult patients and assess the success rate, complications, and overall effectiveness of the procedure. The results of this study could have significant implications for clinical practice, providing clinicians with a better understanding of the potential benefits and risks of using this technique for central venous access in adult patients.

Received: 15-05-2023 **Revised:** 13-06-2023 **Accepted:** 26-06-2023 **Available Online:** 01-09-2023

Access this article online	
Quick Response Code:	**Website:** https://journals.lww.com/jmut
	DOI: 10.4103/jmu.jmu_57_23

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How to cite this article: Singh Y, Pratibhan M, Singh A, Depal V, Sawhney C, Gupta B. The study of the feasibility of ultrasound-guided catheterization of the right brachiocephalic vein in adult patients: A prospective observational study. J Med Ultrasound 2024;32:143-7.

Materials and Methods

This single-center prospective study was conducted after getting approval from the Institutional Ethics Committee of AIIMS, New Delhi (Approval No. IEC-620/02.11.2018). Eighty ASA Grade 1–3 patients, aged between 18 and 65 years, admitted to our hospital from December 15, 2018, to December 31, 2020, for elective and emergency operative procedures under general anesthesia requiring central venous catheterization, were included in the study. Patients who had coagulopathy with an INR >1.5, a platelet count of <50,000/mL, infection at the insertion site, cervical spine fractures, or refused to provide consent were excluded from the study. The primary objective of the study was successful cannulation of the BCV on the first attempt and total catheterization time, while the secondary objective was to identify the ideal length of catheter insertion, the number of attempts required if catheter insertion failed on the first attempt, insertion failure, procedural difficulties, and complications. Major complications included pneumothorax, hemothorax, and arterial puncture. Minor complications included hematomas, vein trans fixation, and thyroid puncture, which were identified with the help of ultrasound scanning. Failure was defined as being unable to put the CVC into the initially chosen site for at least three attempts and/or requiring a side or site change.

All US-guided BCV cannulations were done with the help of the SonoSite FUJIFILM S-Nerve ultrasound device. In all cases, a 6–13 MHz linear-array US probe was used. All procedures were carried out with a J-tip guidewire and a 5-mL syringe attached to an 18-G introducer needle. 7 French B-brawn catheterization sets (Certofix Trio Duo V 720) were used for all catheterization procedures.

All catheterizations during the study period were performed in an operating room by 6 anesthesiologists with a minimum of 6 years of experience (i.e. those who have completed 3 years of junior residency and 3 years of senior residency). After a thorough preanesthetic evaluation, standard ASA monitoring was performed, and preoperative vital signs were noted. General anesthesia was induced with propofol, and the airway was secured with a cuffed endotracheal tube after adequate muscle relaxation was achieved using suxamethonium or cisatracurium, depending on the patient's profile. BCV catheterization was performed using Seldinger's technique, as detailed below:

A preliminary ultrasound-guided scout scan of the right BCV was done, and the nearby anatomical structures were visualized [Figure 1]. A supraclavicular approach with a longitudinal in-plane needle approach was employed for BCV catheterization. A transverse plane of the IJV was initially obtained to locate the BCV. After that, the probe was moved downwards to the supraclavicular fossa. It was tilted anteriorly to examine the subclavian artery, followed by the subclavian vein and BCV junction [Figure 2]. The needle was inserted in-plane from the lateral aspect towards the subclavian-BCV junction [Figure 3]. A complete visualization of the trajectory

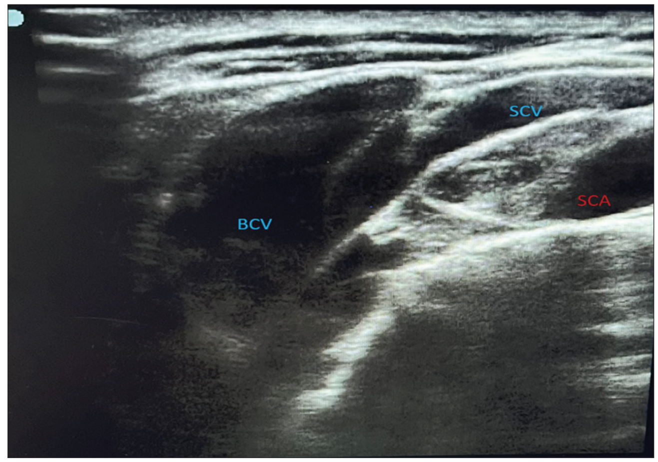

Figure 1: Ultrasound image showing the subclavian artery and the subclavian vein and BCV junction. BCV: Brachiocephalic vein, SCV: Superior vena cava, SCA: Subclavian artery

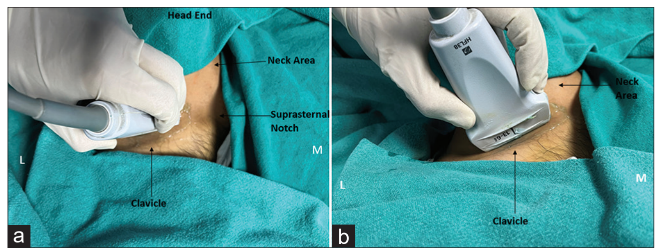

Figure 2: (a and b) The position and orientation of the probe

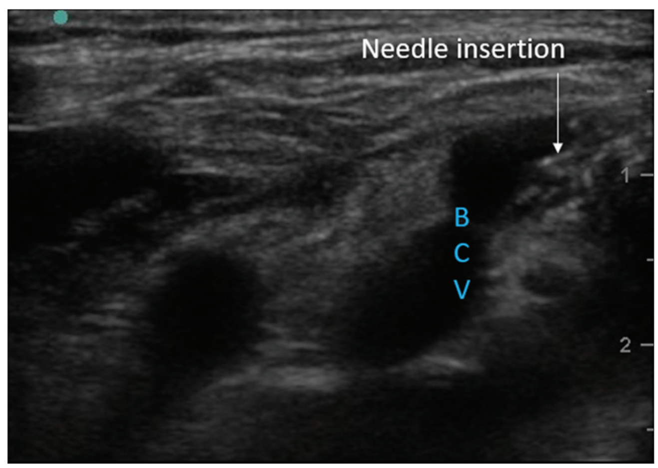

Figure 3: Ultrasound image showing the needle in the BCV. BCV: Brachiocephalic vein

of the needle was essential for the successful and safe catheterization of the BCV. The guide wire was then advanced after confirmation of its intravascular location [Figure 4]. The catheter was threaded along the guide wire, and its location was confirmed after the successful aspiration of free blood flow from all the ports. The CVC was secured with sutures, and a sterile dressing was applied. The catheterization time, number of attempts, and immediate complications were noted. The catheterization time was taken from the first skin puncture

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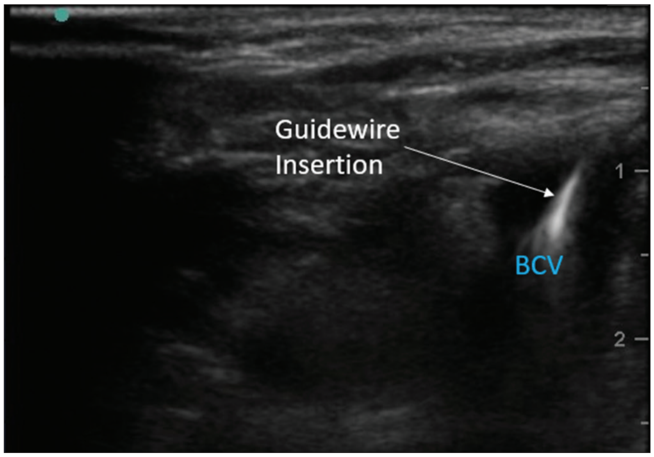

Figure 4: Ultrasound image showing the guidewire in the BCV. BCV: Brachiocephalic vein

to successful guidewire insertion. Successful catheterization was described as the correct placement of the catheter with the aspiration of free blood flow. Every attempt is described as a skin puncture. The position of the central vein tip was assessed by a chest radiograph after the procedure, and the length of the catheter inserted in centimeters was noted. It was considered correct if the tip was just above the tracheal carina. The catheter was repositioned based on the chest radiographs.

Statistical analysis

R software was used to perform all the statistical analyses. Continuous data are provided as mean, standard deviation, median, and interquartile range, where appropriate, whereas categorical data are reported as frequency and percentage.

Results

Nightly-eight patients were screened for likely inclusion in the study. Eighty-seven patients fulfilled the inclusion criteria. Seven patients were excluded due to a lack of consent, the presence of coagulopathy, or infection at the insertion site. The final cohort comprised 80 patients. The mean age of the patients was 43.3 years, and 55% were male. The mean time of guide wire insertion was 31.26 s (19–58 s) and catheter insertion was 88.44 s (63–145 s). The mean length of catheter insertion was 10.46 cm [Table 1]. The guidewire was successfully implanted in 74 of 80 patients on the first attempt and in 6 of 80 patients on the second attempt. No patient required a third attempt at guidewire placement. On the first attempt, a CVC was placed in all the patients [Table 2]. None of the patients experienced major or serious complications such as cardiac arrhythmia, tension pneumothorax, hemothorax, or thromboembolism. No difference in outcome was observed among 6 anesthesiologists who had done the BCV cannulations.

Table 1: Procedural characteristics during brachiocephalic vein cannulation

Parameters	BCV canulations (*n*=80)
Age	43.3±18.23
Sex, *n* (%)	
Female	36 (45)
Male	44 (55)
Time to guidewire insertion (s) mean (minimum–maximum)	31.26 (19–58)
Time to catheter insertion (s) mean (minimum–maximum)	88.44 (63–145)
Length of catheter insertion (cm), mean±SD	10.68±0.68

BCV: Brachiocephalic vein, SD: Standard deviation

Table 2: Attempts and complication during central venous access

Parameters	Guidewire insertion	Catheter insertion
First attempt	74/80	80/80
Second attempt	6/80	-
Complications	Nil	Nil

Discussion

The present study showed that the supraclavicular approach to ultrasound-guided BCV catheterization had a good first-attempt success rate, reduced procedural difficulty, and minimal complications. In 2014, Jordan *et al*. reported the US-guided placement of the CVC in the BCV. The success rate of BCV catheterization was 100%, suggesting the technique was practicable with a low complication and infection rate. The only major limitation is the small number of patients.[7]

We used the in-plane approach for the canulation of the BCV. The US probe was placed in the supraclavicular region and positioned parallel to the clavicle. The IJV was located using the ultrasound image, and the probe was moved until the junction with the subclavian vein was found. The BCV is cannulated using an in-plane longitudinal approach while the needle's progress is monitored on the ultrasound image. The guidewire is introduced, which moves along the long axis of the vein, following the route of the vessel closely.

The catheterization of the BCV has certain benefits over the IJV, such as a thinner tissue structure that helps to keep the BCV lumen open even during changes in hemodynamic and respiratory status. It is also less likely to overlap with other nearby arteries, such as brachiocephalic arteries or the carotid, and the exit of the catheter is located away from the naso-buccal area, which reduces the risk of oropharyngeal bacteria contamination.[8,9] In addition, the BCV is easily identifiable using ultrasound. Because the BCV is far from the pleura and the needle's orientation is parallel to the pleural membrane, the danger of pleural puncture is reduced.[10] Another advantage of this procedure is that when pressure is applied with the US probe, the BCV is not compressed and does not collapse.[11,12]

A disadvantage of this technique is that the procedure is slightly difficult for the novice and less experienced clinician. Proficient hand-eye coordination is needed during the needle puncture and guidewire placement to improve the first-attempt success rate in the plane approach. There are certain situations in

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which BCV cannulation should be avoided. The first is when a dialysis catheter is required because it needs a straight path into the vessel, which is not possible with the BCV approach. The second situation is when a person has a coagulopathy, which makes it difficult to compress the BCV if there is bleeding.[13]

There is limited research that has studied ultrasound-guided BCV cannulation in adults. In a retrospective study, Beccaria *et al*. have compared US-guided supraclavicular BCV with IJV catheterization in 994 patients.[14] In the BCV group, he reported a success rate of 96.4% while in the IJV group, he reported a success rate of 96.6%. Other factors that were compared were first-pass failure rate, overall failure rate, procedural difficulties, and safety. The IJV technique was shown to have more procedural difficulty than the BCV strategy, while the BCV group had more complications (4.6% vs. 3.8%). However, no acute complications were identified in our study following BCV cannulation.

In our study, the first-attempt success rate for BCV cannulation was 92.5% (74 out of 80). Aydin *et al*. recently reported a success rate of 97.6% with BCV catheterization and 97.7% with IJV catheterization in a prospective trial of 86 patients, concluding that supraclavicular BCV cannulation is not inferior to IJV cannulation.[13] In their study, Gowda and Desai reported a first-attempt success rate of 81.81% in the BCV group and 76.36% in the IJV group, and the cannulation attempt was not significant.[15] Other investigations have found that supraclavicular BCV cannulations in adult patients have an overall success rate of 98.3%–100%.[16-18]

In our study, the time for guidewire insertion for BCV cannulation was 31.26 s (19.58 s). Gowda and Desai[15] reported that the time for guidewire insertion was higher in the IJV group than in the BCV group (46.14 ± 30.39 vs. 43.83 ± 26.27), which was statistically not significant. Further, the time to catheter insertion in our study was 88.44 (63–145) s. However, Gowda and Desai[15] noted that the time for catheter insertion was higher in the IJV group than in the BCV group (175.61 ± 58.55 vs. 150.70 ± 64.26, $P = 0.03$), which was statistically significant. This shows that cannulation in BCV is faster, which is consistent with our findings as well. The reason is that the BCV is intrathoracic, has a greater lumen (as it receives blood from both the SCV and IJV), better visibility, and is not collapsing and moving with respiration. However, Aydın *et al*. reported that there was no significant difference in catheterization time between the BCV and IJV groups.[13]

There were no early complications such as vascular punctures, minor bleeding, or hematomas. This may be due to the fact that all catheterizations were performed under US guidance and by experienced clinicians.

Limitations

There are many limitations to our study. First, there is a lack of follow-up data regarding long-term complications such as thrombosis and stenosis. The second limitation was that all catheterizations were performed in US-guided procedures by experienced clinicians. If the catheterizations had been done by less experienced clinicians, the results could have been different. Third, the study was not blinded. The unique design of the study restricted the blinding of the investigator collecting the data. Fourth, we have not compared this technique with other conventional sites of central venous cannulation suh as IJV, subclavian vein, and femoral vein. A well-designed randomized controlled trial comparing BCV catheterization with other conventional sites is needed to evaluate its safety and feasibility.

Conclusion

We conclude that, based on the available evidence, it appears that the US-guided BCV catheterization may be a viable alternative to other sites of central venous cannulation with fewer complications. However, it is important to note that this conclusion is based on a limited amount of research, and further studies, including larger trials and meta-analyses, are needed to confirm these findings and evaluate the safety of this technique.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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