Section: Anaesthesiology

Original Research Article

COMPARISON OF IN-PLANE APPROACH WITH ANTERIOR OUT-OF-PLANE APPROACH IN ULTRASOUND GUIDED SUPRACLAVICULAR SUBCLAVIAN VEIN CANNULATION: A RANDOMIZED CONTROL TRIAL

Preeti Thakur[1], Dheeraj Saxena[2], Gaurav Mishra[3]

[1]Junior Resident, Department of Anaesthesiology, SRMS IMS, Bareilly, Uttar Pradesh, India
[2]Professor, Department of Anaesthesiology, SRMS IMS, Bareilly, Uttar Pradesh, India
[3]Associate Professor, Department of Anaesthesiology, SRMS IMS, Bareilly, Uttar Pradesh, India

Received *: 02/03/2025*
Received in revised form *: 18/04/2025*
Accepted *: 06/05/2025*

Corresponding Author:
Dr. Dheeraj Saxena,
Junior Resident, Department of Anaesthesiology, SRMS IMS, Bareilly, Uttar Pradesh, India.
Email: drsdheeraj@gmail.com

DOI: 10.70034/ijmedph.2025.3.630

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2025; 15 (3); 3446-3450

ABSTRACT

Background: Ultrasound-guided subclavian vein cannulation is integral to perioperative and critical care. While the in-plane approach enables continuous needle visualization, it may be limited by anatomical constraints in the supraclavicular region. This study aims to compare the first pass success rate between in-plane and anterior out-of-plane approaches in ultrasound-guided supraclavicular subclavian vein cannulation, and to evaluate differences in cannulation time, puncture time, operator satisfaction, and complication rates.

Materials and Methods: This randomized controlled trial was conducted at SRMS, Bareilly, following institutional ethics committee approval and CTRI registration. After written informed consent, 128 adult patients undergoing elective surgeries requiring central venous access were randomized into in-plane (n=64) and out-of-plane (n=64) groups. Procedures were performed under general anesthesia using a linear ultrasound probe (8–15 MHz). Outcomes included first pass success, time to venous puncture and cannulation, operator satisfaction (Likert scale), and complications. Data were analyzed using Chi-square/Fisher's exact test for categorical variables and t-test/Mann–Whitney U test for continuous variables.

Results: The out-of-plane group had significantly higher first pass success (90.6% vs. 75.0%, $p<0.05$), shorter mean venous puncture time (14.1 ± 3.8 vs. 18.4 ± 4.6 sec, $p<0.05$), and cannulation time (39.8 ± 6.3 vs. 45.2 ± 7.1 sec, $p<0.05$). Operator satisfaction was greater (4.1 ± 0.6 vs. 3.4 ± 0.7), and complications were fewer (4.7% vs. 10.9%).

Conclusion: The anterior out-of-plane approach offers higher efficacy and safety over the in-plane technique for ultrasound-guided supraclavicular subclavian vein cannulation.

Keywords: Ultrasound-guided cannulation; Subclavian vein; Supraclavicular approach; Central venous catheterization; In-plane vs out-of-plane technique.

INTRODUCTION

Central venous catheterization is an essential component of perioperative care, enabling advanced hemodynamic monitoring and administration of critical therapies. Among the available access routes, the subclavian vein remains a preferred site, particularly when internal jugular or femoral access is contraindicated due to thrombosis or infection.[1,2] Traditionally, the subclavian vein can be approached via the infraclavicular or supraclavicular route, each with its own advantages and limitations.[3]

The infraclavicular approach, while commonly practiced, presents certain technical challenges. The needle trajectory beneath the clavicle can be obstructed by bony structures, limiting visibility and increasing the risk of complications such as catheter

misplacement and pneumothorax.[4] In contrast, the supraclavicular approach offers a more superficial and consistent anatomical window, providing direct access to the brachiocephalic venous confluence.[3,5] With the increasing availability of high-resolution ultrasound devices, ultrasound-guided vascular access has revolutionized central venous cannulation by significantly reducing complication rates and improving procedural success compared to landmark-based techniques.[6,7] While the in-plane ultrasound technique—inserting the needle parallel to the transducer—allows continuous visualization of the needle shaft, it may be limited by anatomical variations and restricted access in the supraclavicular region.[8]

In this context, we explore the novel anterior out-of-plane approach for supraclavicular subclavian vein cannulation. Unlike the conventional in-plane technique, this approach involves needle insertion at the midpoint of the probe's long axis, targeting the confluence of the internal jugular vein (IJV) and subclavian vein. This anatomical location, characterized by a larger vessel diameter and a clearer safety margin, potentially facilitates easier cannulation with fewer complications.[9,10]

This randomized controlled trial compares the first pass success rate of in-plane versus anterior out-of-plane approaches in ultrasound-guided supraclavicular subclavian vein cannulation. Secondary outcomes include puncture time, cannulation time, operator satisfaction, and complication rates, aiming to optimize vascular access and improve patient safety.

MATERIALS AND METHODS

This randomized controlled trial was conducted at SRMS, Bareilly, to compare the efficacy and safety of the in-plane versus anterior out-of-plane approach in ultrasound-guided supraclavicular subclavian vein cannulation. Adult patients over 18 years of age, admitted for elective surgical procedures that required perioperative central venous access under general anesthesia and mechanical ventilation, were enrolled. Patients with coagulopathies, anatomical deformities of the neck or chest wall, or local infection or scarring at the puncture site were excluded from the study. Eligible participants were randomly assigned to two groups—Group 1 (in-plane approach) and Group 2 (anterior out-of-plane approach)—using computer-generated block randomization with blocks of sizes 4 and 6. Allocation concealment was ensured using the SNOSE (Serially Numbered Opaque Sealed Envelope) method. A convenience sampling technique was applied for participant recruitment.

All procedures were performed by anesthesia residents who had prior experience of at least 20 successful subclavian vein cannulations. After obtaining informed consent as per ICMR guidelines, demographic data such as age, sex, height, and weight were recorded. Standard monitors were attached, and general anesthesia with endotracheal intubation was carried out. The patient was positioned supine with the head rotated 30 degrees contralaterally, and a wedge was placed between the scapulae. A high-frequency linear ultrasound probe (8–15 MHz) was used to identify the confluence of the internal jugular and subclavian veins. For the in-plane approach, the needle was introduced at the lateral edge of the ultrasound probe footprint at an angle of 45 degrees, and the entire needle path was visualized as it advanced toward the vein. Once venous entry was confirmed by aspiration of blood and visualization of the needle tip in the lumen, catheterization was completed using the Seldinger technique.

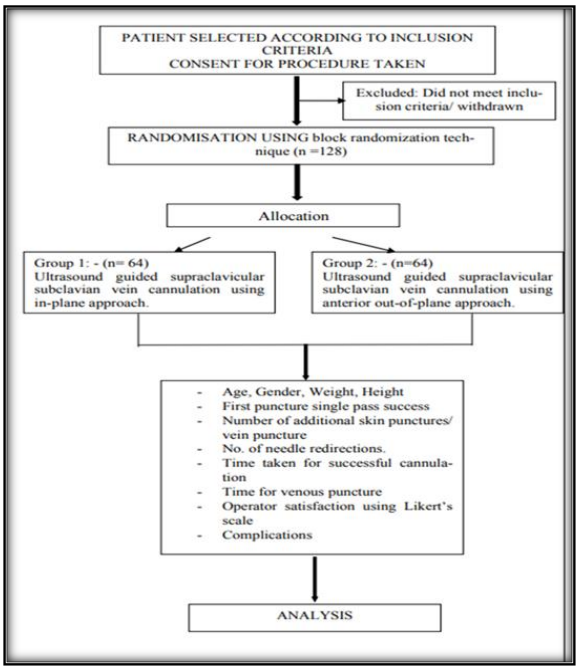
For the anterior out-of-plane approach, the needle was inserted at the midpoint of the probe footprint, angulated 5–10 degrees from the probe's axis, and guided using real-time ultrasound based on the previously measured depth of the vein. The needle was not advanced beyond this depth to avoid inadvertent complications. Once venous access was confirmed with flashback of blood, the probe was set aside, and the needle was stabilized manually. Catheterization followed using the standard Seldinger technique. In both groups, aspiration of blood from all three lumens confirmed correct placement, and the catheter was secured with sutures and a sterile dressing. Post-procedure chest radiographs were obtained to confirm catheter tip location and detect any complications such as pneumothorax.

A successful attempt was defined as catheterization achieved in a single needle pass without any additional skin or vein punctures. The number of needle redirections was noted. An assistant recorded procedural times using a stopwatch—starting at needle insertion, recording the time of flashback (venous puncture), and the time when aspiration from all three lumens was confirmed (successful cannulation). Operator satisfaction was evaluated using a 5-point Likert scale (Poor to Excellent). Patients requiring more than three attempts or not undergoing cannulation due to other reasons were withdrawn from the study. Adverse events, such as arterial puncture, hematoma, hemothorax, catheter misplacement, or pneumothorax, were recorded and managed as per clinical guidelines.

In-Plane Approach

Out-Of-Plane Approach

The data collected were monitored by the principal investigator and study supervisors for completeness and accuracy. Categorical variables such as gender, first pass success, operator satisfaction, and complications were expressed as frequencies and percentages. Continuous variables like age, height, weight, time for venous puncture, and time for successful cannulation were presented as mean ± standard deviation or median with interquartile ranges depending on the distribution. Chi-square or Fisher's exact tests were used for categorical data, and independent t-test or Mann–Whitney U test for continuous data, based on normality. Sample size was estimated from previous studies, particularly by Vezzani et al,[12] assuming a 72% first pass success rate in the out-of-plane group compared to 48% in the in-plane group, with 80% power and 5% significance. The final calculated sample size was 64 patients per group.



RESULTS

Demographic characteristics such as age, gender distribution, weight, and height were comparable between the two groups, with no significant baseline differences, as shown in [Table 1].

Table 1: Demographic Characteristics of Study Participants.

Variable	In-Plane Group	Out-of-Plane Group
Age (years)	44.9 ± 11.7	45.6 ± 12.3
Gender	38 / 26 (59.4% / 40.6%)	34 / 30 (53.1% / 46.9%)
Weight (kg)	66.5 ± 10.8	64.3 ± 11.6
Height (cm)	163.1 ± 8.9	162.3 ± 9.4

Procedural outcomes demonstrated higher first pass success rates, shorter puncture and cannulation times, and better operator satisfaction in the out-of-plane group, with fewer complications, as shown in [Table 2].

Table 2: Procedural Variables Recorded During Cannulation.

Variable	In-Plane Group	Out-of-Plane Group
First Pass Success (%)	48 (75.0%)	58 (90.6%)
Time for Venous Puncture (sec)	18.4 ± 4.6	14.1 ± 3.8
Time for Successful Cannulation (sec)	45.2 ± 7.1	39.8 ± 6.3
Additional Skin Punctures (n, %)	16 (25.0%)	6 (9.4%)
Needle Redirections (n, %)	12 (18.8%)	4 (6.3%)
Operator Satisfaction (Likert Mean ± SD)	3.4 ± 0.7	4.1 ± 0.6
Complications (Any, n, %)	7 (10.9%)	3 (4.7%)

A detailed analysis of complications revealed a lower incidence of pneumothorax, arterial puncture, and catheter misplacement in the out-of-plane group compared to the in-plane group, as shown in [Table 3].

Table 3: Complications Monitored During and After Cannulation

Complication Type	In-Plane Group (n, %)	Out-of-Plane Group (n, %)	Detection Method	Management Protocol
Pneumothorax	3 (4.7%)	1 (1.6%)	Postoperative chest radiograph	Observation / Chest tube
Arterial Puncture	2 (3.1%)	1 (1.6%)	Bright red pulsatile backflow	Manual compression
Hematoma	1 (1.6%)	0 (0%)	Clinical signs	Supportive care
Hemothorax	1 (1.6%)	0 (0%)	Clinical signs + radiograph	Supportive care
Catheter Misplacement	0 (0%)	1 (1.6%)	Post-insertion chest radiograph	Catheter repositioning

DISCUSSION

This randomized controlled trial revealed that the anterior out-of-plane approach had superior procedural outcomes compared to the in-plane technique in ultrasound-guided supraclavicular subclavian vein cannulation. Demographic parameters such as age (44.9 ± 11.7 vs. 45.6 ± 12.3 years), weight (66.5 ± 10.8 vs. 64.3 ± 11.6 kg), and height (163.1 ± 8.9 vs. 162.3 ± 9.4 cm) were comparable between groups, minimizing confounding factors—similar to the baseline matching reported by Czarnik et al and Vezzani et al.[11,12]

In this study, the first pass success rate was notably higher in the out-of-plane group (90.6%) compared to the in-plane group (75.0%), aligning with Vezzani et al,[12] who found a higher first puncture success in the short-axis (out-of-plane) group (72% vs. 48%). Gorchynski et al,[13] also reported a high overall success rate (89.7%) using a modified supraclavicular approach, consistent with our out-of-plane results. Jung et al,[14] observed 87% first-pass success using CT-guided planning for supraclavicular access, supporting the anatomical advantage of this approach. Procedural times were shorter in the out-of-plane group for both venous puncture (14.1 ± 3.8 sec) and cannulation (39.8 ± 6.3 sec) compared to the in-plane group (18.4 ± 4.6 sec and 45.2 ± 7.1 sec), similar to the shorter insertion time reported by Vezzani et al,[12] in the short-axis group.

Operator satisfaction was higher with the out-of-plane technique (4.1 ± 0.6 vs. 3.4 ± 0.7), a finding not reported in prior literature but indicating improved ergonomics. The overall complication rate was lower in the out-of-plane group (4.7% vs. 10.9%), especially for pneumothorax (1.6% vs. 4.7%) and arterial puncture (1.6% vs. 3.1%), in line with the trend noted by Chen et al,[15] in their meta-analysis favoring supraclavicular over infraclavicular access. Yoffa et al,[3] historically advocated the supraclavicular approach due to its anatomical safety and simplicity, findings echoed in our study. While Czarnik et al,[11] and Jung et al,[14] reported even lower complication rates, the variation may reflect differences in sample size and operator experience. A unique finding in our study was one case of catheter misplacement in the out-of-plane group, which emphasizes the need for vigilant post-procedure imaging. Overall, the results reaffirm the clinical efficacy and safety of the out-of-plane approach and are supported by existing literature across different techniques and anatomical routes.

Strengths and Limitations of the Study

The strengths of this study include its randomized controlled design, strict allocation concealment, and use of objective outcome measures such as first pass success, procedure time, and complication rates. All procedures were performed by adequately trained residents, enhancing reproducibility while reflecting real-world clinical practice. However, limitations include the single-center setting, relatively small sample size, and lack of blinding, which may introduce observer bias. Additionally, long-term follow-up for catheter-related complications was not assessed, and results may vary with operator experience, potentially limiting generalizability to different clinical settings or provider skill levels.

CONCLUSION

In conclusion, the anterior out-of-plane approach for ultrasound-guided supraclavicular subclavian vein cannulation demonstrated superior clinical efficacy compared to the in-plane technique, with significantly higher first pass success rates, reduced procedure times, improved operator satisfaction, and fewer complications. These findings support the adoption of the out-of-plane method as a safer and more efficient alternative, particularly in high-risk or time-sensitive scenarios. The consistency of our results with prior literature further strengthens its clinical applicability and highlights the importance of technique optimization in central venous access to improve patient outcomes.

REFERENCES

1. McGee DC, Gould MK. Preventing complications of central venous catheterization. N Engl J Med. 2003 Mar 20;348(12):1123–33.
2. Sznajder JI, Zveibil FR, Bitterman H, Weiner P, Bursztein S. Central vein catheterization: failure and complication rates by three percutaneous approaches. Arch Intern Med. 1986 Feb;146(2):259–61.
3. Yoffa D. Supraclavicular subclavian venepuncture and catheterization. Lancet. 1965 Jan 9;1(7377):614–7.
4. 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 Jul;38(7):1105–17.
5. Buetti N, Mimoz O, Mermel L, Ruckly S, Mongardon N, Dupuis C, Mira JP, Lucet JC, Mégarbane B, Bailly S, Parienti JJ, Timsit JF. Ultrasound Guidance and Risk for Central Venous Catheter-Related Infections in the Intensive Care Unit: A Post Hoc Analysis of Individual Data of 3 Multicenter Randomized Trials. Clin Infect Dis. 2021 Sep 7;73(5):e1054-e1061. doi: 10.1093/cid/ciaa1817. PMID: 33277646.
6. Hind D, Calvert N, McWilliams R, Davidson A, Paisley S, Beverley C, Thomas S. Ultrasonic locating devices for central venous cannulation: meta-analysis. BMJ. 2003 Jul 12;327(7411):361.
7. Wu SY, Ling QY, Wang Y, Wang ZY, Li Y, Wang XY. Real-time two-dimensional ultrasound-guided subclavian vein cannulation: a systematic review and meta-analysis. Anesthesiology. 2016 Apr;124(4):958–75.
8. Vogel JA, Haukoos JS, Erickson CL, Liao MM, Theoret J, Sanz GE, Kendall J. Is long-axis view superior to short-axis view in ultrasound-guided central venous catheterization? Crit Care Med. 2015 Apr;43(4):832-9. doi: 10.1097/CCM.0000000000000823. PMID: 25517477; PMCID: PMC4436655.
9. Patrick SP, Tijunelis MA, Johnson S, Herbert ME. Supraclavicular subclavian vein catheterization: the forgotten central line. West J Emerg Med. 2009 May;10(2):110-4. PMID: 19561831; PMCID: PMC2691520.
10. Saugel B, Scheeren TWL, Teboul JL. Ultrasound-guided central venous catheter placement: a structured review and recommendations for clinical practice. Crit Care. 2017 Jun 6;21(1):225.

11. Czarnik T, Gawda R, Perkowski T, Weron R. Supraclavicular approach is an easy and safe method of subclavian vein catheterization even in mechanically ventilated patients. Anesthesiology. 2009;111:334±9.
12. Vezzani A, Manca T, Brusasco C, Santori G, Cantadori L, Ramelli A, et al. A randomized clinical trial of ultrasound-guided infra-clavicular cannulation of the subclavian vein in cardiac surgical patients: short-axis versus long-axis approach. Intensive Care Med. 2017;43(11):1594-1601.
13. Gorchynski J, Everett WW, Pentheroudakis E. A modified approach to supraclavicular subclavian vein catheter placement: The pocket approach. Calif J Emerg Med. 2004;5:50±4.
14. Jung CW, Seo JH, Lee W, Bahk JH. A novel supraclavicular approach to the right subclavian vein based on Three-dimensional computed tomography. Anesth Analg. 2007; 105:200-4.
15. Chen, Qi, et al. "Comparative Evaluation of the Clinical Safety and Efficiency of Supraclavicular and Infraclavicular Approaches for Subclavian Venous Catheterization in Adults: a Meta-analysis." The American Journal of Emergency Medicine, 2020;38(7); 1475-1480.