A Comparison of Success Rates in Ultrasound Guided Subclavian Vein Cannulation through Supraclavicular and Infraclavicular Approach: A Randomised Trial

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Central venous catheterization, Neuroanesthesia, randomized controlled trial, Drugs, Puncture

ABSTRACT

Introduction: In intensive care units (ICUs), central venous catheterisation (CVC) is crucial for administering drugs, supplying fluids, and tracking haemodynamics. In critically sick adult patients in India, this study compares the efficacy of infraclavicular (IC) and supraclavicular (SC) ultrasound-guided methods for subclavian vein cannulation.

Methodology: A prospective randomized controlled trial was carried out at SRM Medical College Hospital & Research Centre from August 2022 to August 2024. A total of 100 ICU patients were randomly assigned to either the SC or IC group. The study analyzed key variables such as total procedure time, venous visualization time, venous puncture time, number of attempts, catheterization time, and complications. Data analysis was performed using SPSS version 21, with statistical significance defined as $p < 0.05$.

Results: In the study, the mean age of patients in the SC group was 41.58±15 years, compared to 44.2±12.3 years in the IC group, with similar gender distributions across both groups. Procedural metrics revealed that the SC group had a significantly shorter total procedure time (174.1±12.7 minutes) compared to the IC group (213.3±24.2 minutes) ($p < 0.001$). The SC group also achieved faster venous visualization (45±16.3 minutes) compared to the IC group (62.3±16.8 minutes) ($p < 0.001$). Venous puncture time was shorter in the SC group (33.8±4.2 minutes) than in the IC group (43.1±4.3 minutes) ($p < 0.001$). Additionally, the SC group required fewer attempts (1.4±0.5) compared to the IC group (2±0.9) ($p < 0.001$) and had a shorter total access time (5.6±1.3 minutes) versus the IC group (8.2±2.8 minutes) ($p < 0.001$). The IC approach was associated with higher complication rates, including arterial puncture and catheter malposition.

Discussion: Significant benefits were seen between the SC and IC approaches: shorter procedure durations, faster venous visualisation and puncture, fewer failed attempts at successful catheterisation, and shortened access times. These results imply that the SC method is safer and more effective.

Conclusion: For critically sick patients, the SC method to subclavian vein cannulation offers significant advantages in terms of effectiveness, success rates, and decreased complications. The SC strategy, which has the potential to enhance patient outcomes, is supported by this study as the recommended CVC technique in intensive care units. It is recommended to do further studies to confirm these results.

1. Introduction

Central venous catheterization (CVC) is a crucial procedure utilized in about 75% of intensive care patients to administer medications, fluids, parenteral nutrition, and to monitor hemodynamic status. While the internal jugular vein (IJV), subclavian vein (SV), proximal axillary vein (AV), and femoral vein (FV) are frequently used for this purpose, there are specific circumstances where the IJV and femoral vein may be restricted or less suitable for use[1]. Neuroanesthesia typically avoids internal jugular vein (IJV) cannulation due to the risk of the catheter becoming twisted during head positioning for surgery, which can lead to venous congestion and elevated intracranial pressure. Additionally,

inserting a catheter into the femoral vein carries a higher risk of infection and may be unsuitable for some patients due to its associated inconvenience[2].

The subclavian vein (SCV) is becoming more preferred over the internal jugular vein (IJV) for several reasons: it has a lower risk of infection, is more convenient to place in immobilized patients, and minimizes interference during procedures like endotracheal intubation or cardiopulmonary resuscitation. Furthermore, catheterization of the SCV is associated with a reduced risk of thrombosis compared to other catheterization sites[3,4]. With the increasing use of ultrasound-guided (USG) SCV cannulation, both success rates and complication rates have seen notable improvements[5].

SCV cannulation can be carried out using two main techniques: supraclavicular and infraclavicular. The supraclavicular approach offers several advantages, such as increased patient comfort, reduced infection rates, a lower risk of thrombosis, and better catheter tip positioning[6]. The use of ultrasound guidance (USG) has increased because of its enhanced capabilities, such as allowing visualization of the needle's trajectory, its path, and the position of superficial veins without interference from bones[7].

Conversely, although the infraclavicular approach is commonly used, it is associated with a higher incidence of complications, including puncture of the subclavian artery, pneumothorax, haemothorax, and catheter misplacement. However, there is a notable lack of documented evidence comparing the effectiveness of supraclavicular and infraclavicular techniques specifically in the adult Indian population. This gap highlights the need for research to evaluate the success rates, procedural efficiency, and complications of both approaches in adult ICU patients in India[8]. This study aims to address this gap by conducting a comparative review of ultrasound-guided supraclavicular and infraclavicular techniques for subclavian vein cannulation in critically ill adult Indian patients. The primary objectives are to assess success rates, procedure duration, and both mechanical and infectious complications associated with each technique. By evaluating the effectiveness and safety of these methods in the Indian population, the study seeks to refine catheterization practices in ICU settings and ultimately enhance patient outcomes.

2. Methodology

This prospective randomized controlled trial (RCT) aimed to evaluate the effectiveness of ultrasound-guided supraclavicular versus infraclavicular approaches for subclavian vein cannulation, focusing on success rates, venous puncture times, and potential complications. Conducted at SRM Medical College Hospital & Research Centre from August 2022 to August 2024, the study involved ICU patients regardless of comorbidities. A total of 100 patients, with 50 in each approach group, were selected according to specific inclusion and exclusion criteria. The sample size was determined using a statistical formula for comparing two independent means, anticipating a mean difference of 5.2 seconds in catheterization time and a standard deviation of 7.98. Participants were recruited consecutively, and informed written consent was obtained. Randomization was achieved through computer-generated numbers and the sealed envelope method to ensure impartial allocation. Critically ill patients requiring central venous catheter (CVC) insertion were randomly assigned to either Group A (supraclavicular approach) or Group B (infraclavicular approach) based on strict criteria. Inclusion criteria included ICU patients aged 18 to 65 who required CVC insertion and provided consent, while exclusion criteria included factors such as infection at the cannulation site, use of immunosuppressive drugs, infective endocarditis, coagulopathies, deformities, recent trauma or infection at the site, spine deformity, contralateral pneumothorax/hemothorax, pregnancy, and BMI over 30. Routine tests such as CBC, BT, CT, coagulation profile, HIV, and HBSAG were performed on all patients. The procedures were carried out in the ICU with peripheral venous access secured and proper sterile preparation. For the supraclavicular approach, patients were placed in a supine position with a 20–30-degree Trendelenburg tilt, using a linear vascular transducer for visualization. The needle was advanced until it entered the vessel. For the infraclavicular approach, patients were also positioned supine, with the probe placed in the infraclavicular fossa, and the needle inserted and visualized in the long axis until it entered the vessel. Data were entered into Microsoft Excel 2013, verified for accuracy,

and analyzed using SPSS version 21. Continuous variables were summarized with means and standard deviations, while categorical variables were presented as frequency distributions and percentages. Chi-square tests were used to examine associations between categorical variables, with a p-value < 0.05 indicating statistical significance. Data were presented in tables and bar charts. The patient proforma recorded essential demographics, physical parameters, and pre-anesthetic assessments. During the procedure, heart rate, blood pressure, SpO2 levels, venous puncture time, number of attempts, total access time, and complications were monitored. The study aimed to assess the efficacy and safety of these techniques in the Indian population, aiding in optimal catheterization approach selection and enhancing patient outcomes in ICU settings.

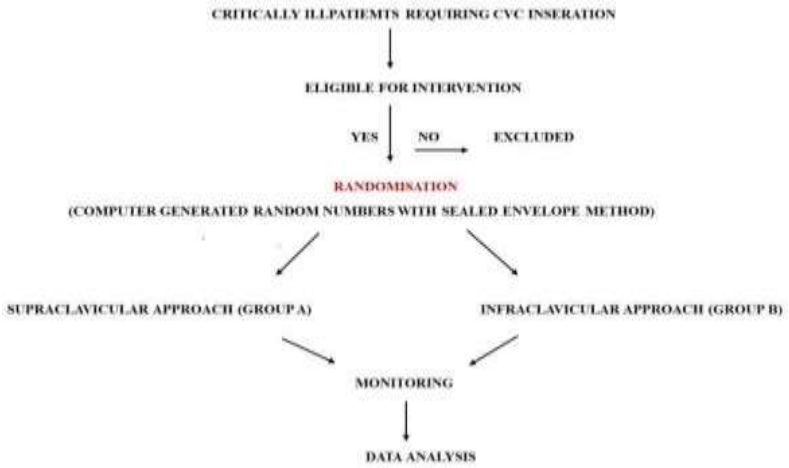

Figure 1- Flow Diagram Illustrating the study process

3. Results

Table 1: Distribution of study participants according to age

Age	Group				Total		P value
	SC		IC				
<20	4	8.0%	0	0.0%	4	4.0%	
20-40	20	40.0%	16	32.0%	36	36.0%	
40-60	19	38.0%	30	60.0%	49	49.0%	
>60	7	14.0%	4	8.0%	11	11.0%	
Mean±SD	41.58±15		44.2±12.3				0.052

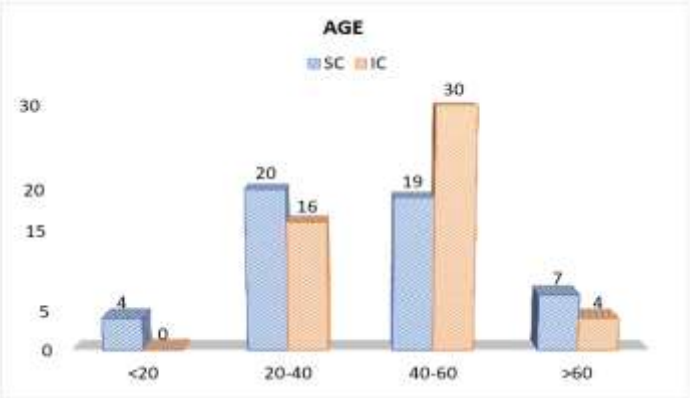

Figure 2: Distribution of study participants according to age

Table 2: Distribution of study participants according to gender

Gender	Group				Total		P value
	SC		IC				
Male	30	60.0%	31	62.0%	61	61.0%	0.838
Female	20	40.0%	19	38.0%	39	39.0%	

Figure 3: Distribution of study participants according to gender

Table 3: Comparison of time parameters between groups

Variables	SC	IC	P value
Total Procedure time	174.1±12.7	213.3±24.2	<0.001*
Venous visualization	45±16.3	62.3±16.8	<0.001*
Venous puncture time	33.8±4.2	43.1±4.3	<0.001*

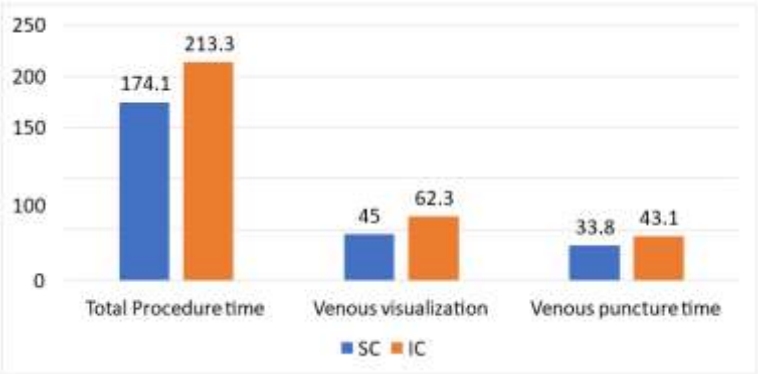

Figure 4: Comparison of time parameters between groups

Table 4: Comparison of catheterization, attempts and access time between groups

Variables	SC	IC	P value
Catheterization	127.8±4.7	132.6±7.1	<0.001*
No. of attempts	1.4±0.5	2±0.9	<0.001*
Total access time	5.6±1.3	8.2±2.8	<0.001*

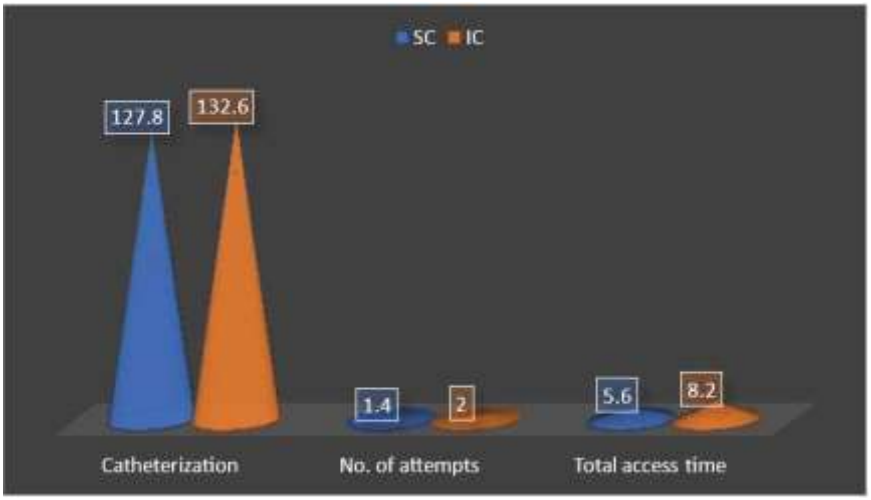

Figure 5: Comparison of catheterization, attempts and access time between groups

The study analysed the distribution of participants based on age and gender, as well as compared various procedural parameters between the supraclavicular (SC) and infraclavicular (IC) approaches. The age distribution revealed that participants under 20 years were more represented in the SC group (8.0%) than in the IC group (0.0%). The 20-40 age group constituted 40.0% in the SC group and 32.0% in the IC group. Participants aged 40-60 years were predominant, especially in the IC group (60.0%), compared to the SC group (38.0%). The mean age was slightly lower in the SC group (41.58±15) than in the IC group (44.2±12.3), with a P value of 0.052, indicating a marginal significance. Gender distribution was similar between the groups, with males constituting 60.0% in the SC group and 62.0% in the IC group, and females making up 40.0% and 38.0%, respectively (P value 0.838). Procedural parameters highlighted significant differences: total procedure time was shorter for the SC group (174.1±12.7 minutes) compared to the IC group (213.3±24.2 minutes), with a P value <0.001. Venous visualization and venous puncture times were also significantly quicker in the SC group (45±16.3 minutes and 33.8±4.2 minutes, respectively) compared to the IC group (62.3±16.8 minutes and 43.1±4.3 minutes, respectively), both with P values <0.001. Furthermore, catheterization time, the number of attempts, and total access time were all notably better in the SC group (127.8±4.7 minutes, 1.4±0.5 attempts, and 5.6±1.3 minutes, respectively) compared to the IC group (132.6±7.1 minutes, 2±0.9 attempts, and 8.2±2.8 minutes, respectively), all with P values <0.001. These findings underscore the efficiency and potential advantages of the supraclavicular approach for subclavian vein cannulation in critically ill patients.

4. Discussion

In clinical settings, central venous catheterization is employed to administer medications, fluids, and monitor hemodynamics. The choice between supraclavicular (SC) and infraclavicular (IC) approaches can impact the procedure's efficiency, success rate, and potential complications. In this presentation, we will examine research from the literature comparing these two methods[9-11]. We aim to synthesize the results to highlight the advantages and disadvantages of the SC and IC approaches, assisting doctors in enhancing procedural outcomes and patient care. In our study, the mean ages, gender distributions, and average BMIs of the Supraclavicular (SC) and Infraclavicular (IC) groups were comparable ($p > 0.05$). This balanced comparison ensures the reliability of our findings by minimizing confounding factors that could affect the results. Our study revealed significant benefits of the SC technique in terms of localization, overall procedure time, venous visibility, puncture success, catheterization, number of attempts, and total access time. Also, in the studies done by Momin et al.[12], Bodhke et al.[13], and Prasad et al.[14], found faster process times and fewer attempts using the SC method.

Mahmoud et al.[15] observed that the IC method resulted in fewer punctures and shorter puncture times. This discrepancy could be attributed to differences in patient demographics, procedural techniques, and operator experience among the studies. Consistent with previous research, our study found a

significantly higher incidence of catheter malposition with the IC approach compared to the SC technique. This underscores the importance of meticulous technique and accurate catheter placement, particularly in methods with a higher risk of misplacement. The increased rate of malposition in the IC group highlights the need for careful monitoring and vigilance to minimize catheter-related complications.

The current study found that the IC technique was associated with more complications compared to the SC strategy, which aligns with the findings of Bodhke et al.[13], Khapung et al.[16], and Mahmoud et al.[15], who also reported higher complication rates with the IC approach. Potential issues with the IC method include aortic puncture, hematoma, and catheter malposition. The SC approach demonstrated a higher success rate with fewer attempts compared to the IC method. This observation is consistent with the results of Momin et al.[12] and Khapung et al.[16], who also reported higher success rates and fewer attempts with the SC approach.

When comparing our study to existing literature, it is important to consider differences in methodologies, sample sizes, and patient demographics. While most studies indicate that the SC approach is generally more efficient and less prone to complications, occasional discrepancies warrant further investigation.

The consistency of our findings with existing research has implications for clinical practice. The SC technique generally shows better efficiency, higher success rates, and fewer complications compared to the IC method. These insights can guide clinicians in selecting the most appropriate central venous catheterization technique based on patient characteristics and operator expertise

The demographic characteristics, comparative analysis, and results of the current study provide insight into the relative effectiveness of SC versus IC central venous catheterization. Although ongoing trends generally favor the SC technique in terms of procedural efficiency and complication rates, variations among studies highlight the need for further research to better understand outcomes and enhance clinical practice.

5. Conclusion

This study highlights the significant benefits of the supraclavicular (SC) approach over the infraclavicular (IC) method for subclavian vein cannulation in critically ill patients, particularly in terms of efficiency, success rates, and fewer complications. The SC approach demonstrated notably shorter procedure times, faster venous visualization and puncture, fewer attempts for successful catheterization, and overall reduced access times compared to the IC approach. These results align with existing literature, which underscores the SC approach's advantages in enhancing patient comfort, reducing infection rates, and lowering the risk of complications such as catheter malposition and arterial puncture. While some discrepancies in results across studies may be due to differences in methodologies, patient demographics, and operator experience, the general consensus favors the SC approach. Therefore, this study advocates for adopting the SC technique as the preferred method for central venous catheterization in ICU settings, aiming to improve patient outcomes and procedural efficiency in the Indian population. Further research with larger sample sizes and diverse populations is needed to validate these findings and refine clinical practices.

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