ORIGINAL ARTICLE

Subclavian Vein Cannulation via Supraclavicular or Infraclavicular Route Which is Better? A Prospective Randomized Controlled Trial

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Abstract

Background and objectives: The subclavian vein is frequently cannulated using ultrasound. There are two techniques of subclavian vein catheterization (SVC): Supraclavicular (SC) and infraclavicular (IC). Though the IC route is often preferred, the SC approach offers several distinct advantages. This study was planned to compare the technique of SVC using SC and IC approaches in terms of catheterization technique and complications in elective surgeries in adults.

Methods: Sixty American Society of Anesthesiologists (ASA) 1, 2, or 3 adult patients posted for elective surgeries under general anesthesia were recruited. Patients were divided into SC or IC groups randomly. Right-sided subclavian vein was cannulated in both the groups ($n = 30$). Visualization time, Likert scale, subclavian vein diameter, skin-to-subclavian vein depth, number of attempts, puncture time, ease of guidewire insertion, catheter insertion time, and total procedural time were observed. A comparison of complications for each approach was noted.

Results: Total procedural time, time to visualization of the subclavian vein, and puncture time was lower for group SC and higher for group IC. Catheter insertion time was higher with the IC approach than with the SC approach. Better ultrasound view scores were seen in group SC than in group IC. The first attempt success rate was higher in group SC than in group IC. Comparatively, lower complications both during and after the procedure were noted in the SC approach than the IC approach.

Conclusion: Ultrasonography (USG) guidance guided SC approach to access the subclavian vein is quicker, relatively secure, and a better technique than the IC approach. Additionally, the SC approach is associated with comparatively fewer immediate and delayed complications.

Keywords: Access, Complications, Infraclavicular, Route, Subclavian, Supraclavicular, Ultrasound.

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Highlight

Supraclavicular (SC) approach to Subclavian vein cannulation offers quicker access and relatively fewer complications compared to infraclavicular (IC) approach.

Introduction

Central venous catheterization (CVC) is a vital intervention in the operation theatre, intensive care unit, and emergency room. Common clinical applications of CVC include central venous pressure (CVP) monitoring in major surgeries, administration of drugs, hyperosmolar solutions and blood products.[1]

Internal jugular vein (IJV) cannulation being the most adopted route for central venous access, it is associated with several problems like proximity to neck vessels leading to arterial puncture, and difficulty in access in obese, edematous, and hypovolemic patients. The subclavian vein is advantageous anatomically owing to its huge caliber, absence of valves, and support of surrounding structures which keeps the vein patent even in shock.[2] Easy nursing care with better patient comfort and low risk of infection make it a desirable route for long-term catheterisation.[3] The right subclavian vein is often preferred over the left subclavian vein due to the absence of a thoracic duct on the right side and comparatively lower pleura.[4] Landmark based approach is reported to be frequently associated with a higher incidence of complications like pneumothorax, arterial puncture, and catheter malposition.[5]

With advances in technology, the use of ultrasound has become the standard of care in medical practice overcoming the limitations of landmark-based techniques. Ultrasound allows real-time visualization of the vein ensuring successful cannulation with fewer attempts and less complication rate.[6]

The subclavian vein can be catheterized using two approaches: SC and IC. Landmark-based IC approach of subclavian venous

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catheterization has been the most widely used technique since its advent by Aubanaic et al. in 1952.[7] In contrast, the SC approach is largely forgotten perhaps due to a lack of training or fear of vital structures in its vicinity. However, the SC approach offers distinct advantages under ultrasonic guidance. This approach allows easier placement of US probe and guidewire insertion due to the straight path of the vein and is associated with a lower incidence of pneumothorax due to increased distance between the subclavian vein and pleura.[8] Ultrasonography guidance (USG) guided IC approach of subclavian vein cannulation has been observed to be difficult in terms of placement of probe due to interference by the acoustic shadow of clavicle.[9] A higher success rate with a better safety profile has been reported with the landmark approach of SC subclavian vein cannulation.[10,11]

Very few studies are available in the literature comparing the efficacy of two approaches using real-time visualization of the subclavian veins under ultrasound in adult surgical patients.[12,13]

Hence, this study was planned to compare the technique of subclavian vein cannulation employing SC and IC approaches with respect of catheterization technique and complication rate in elective surgical procedures in adults.

Hypothesis

The SC route of ultrasound-guided subclavian vein cannulation is better than the IC route with regard to ease of catheterization and associated complications in adult patients undergoing elective surgeries.

Primary Objective

To compare SC and IC routes of ultrasound-guided subclavian vein catheterization (SVC) with respect to ease of catheterization in adult patients undergoing elective surgeries using total procedural time.

Sample Size

The study by Ram Prasad et al., remarked that the total procedural time in the SC approach for SVC group was (177.92 ± 12.46 seconds) and in the IC approach for SVC group was (199.66 ± 18.53 seconds). With these values as reference, the minimum required sample size with 99% power of study and 5% level of significance was calculated as 20 patients to be included for each study group. To lower the margin of error, the total sample size was increased to 60 (30 patients per group).[14]

Formula used for calculations was:

For comparing mean of two groups

$$N \geq 2\frac{(\text{standard deviation})^2}{(\text{mean difference})^2} \times (Z\alpha + Z\beta)^2$$

Where Zα represents value of Z at two sided alpha errors of 5% and Zβ represents value of Z at power of 99% and mean difference is difference in mean values of two groups.

$$\text{Pooled standard deviation} = \sqrt{(S_1^2 + S_2^2)/2}$$

Where standard deviation of SSV group is S_1 and standard deviation of ISV group is S_2.

Calculations

$$\text{Pooled standard deviation} = \sqrt{(12.46^2 + 18.53^2)/2}$$
$$= 15.79$$
$$N \geq \frac{2\,(15.79)^2 \times (1.96 + 2.33)^2}{(21.74)^2}$$
$$\geq 19.41 = 20\,(\text{approx.})$$

Methods

Upon approval by the institutional ethics committee the randomized trial was registered with the clinical trials registry - India CTRI no. CTRI/2021/03/032045 (Registered on: 16/03/2021) the study was started. The study had the primary objective of comparing the SC and IC routes of ultrasound-guided SVC with respect to ease of catheterization in adult patients undergoing elective surgeries using total procedural time. Secondary objectives of the study include comparing the two techniques in respect of time to visualization of the subclavian vein, the diameter of the subclavian vein, time to puncture, attempt number, success, and complication rate.

About 60 American Society of Anesthesiologists (ASA) I, II, or III adult patients posted for elective surgical procedures and requiring CVP cannulation were recruited to participate in this study. Written informed consent was taken from all the subjects before including them in the study.

Patients having distorted anatomy and any congenital vascular anomaly in the neck, contraindications to the CVC insertion (coagulopathies, on anticoagulants, local site infection), posted for emergency surgery, in hypovolemic or septic shock, prior pneumothorax and raised intracranial pressure were excluded from the study. Patients were then randomly allocated into 2 groups; SC and IC, of 30 patients each as per the block randomization technique using the sealed envelope system.

Patient Preparation

All included patients went through a detailed pre-anesthetic check-up and were described about the procedure. After standard general anesthesia induction, subclavian vein cannulation was performed by a single anesthesiologist having experience of at least 20 CVP cannulations under ultrasonic guidance. Patients were than divided into two groups in accord with the route of subclavian vein central line placement namely, group SC group and group IC group.

Ultrasound Scanning

A 7 Fr triple lumen (16G) 16 cm long CVC (CERATOTM, LA-MED HEALTHCARE PVT. LTD.) was placed in each group using a portable ultrasound machine (M-TURBO, SONOSITE, FUJIFILM INC.) with a linear vascular probe (6–13 MHz). After appropriate aseptic precautions, in the SC group, the right IJV was identified and traced down the neck, upon reaching the right IJV-subclavian vein junction at the SC area, the probe was moved laterally to view the right subclavian vein and right brachiocephalic vein in long axis. Pulsed wave doppler was used to rule out the artery. Whereas in the IC group, the transducer probe was placed on the infraclavicular region, so that the clavicle was cranial and subclavian vessels were seen caudally in long axis view. Thereafter, the probe was rotated slightly and tilted with the view of the subclavian artery in order to

obtain the best longitudinal (in-plane) view of the subclavian vein. Using ultrasound guidance the puncturing needle was advanced in-plane under real-time such that lung pleura remained beneath the vessels, away from the needle tip.

Catheterization Dynamics

After puncturing the vessel, a free aspirate of blood and smooth threading of the guidewire was ensured. Successful catheter placement was confirmed by blood drawn through all three ports of the catheter. Another anesthesiologist noted all the required parameters to be studied.

Visualization time was interpreted as the time required from placement of the USG probe to getting a clear picture of the subclavian vein on the display screen. Puncture time was stated as the time needed from the first skin puncture to the blood aspiration from the subclavian vein through the needle. Catheterization time was measured as the time needed to place the catheter from blood drawn through the needle to the successful blood aspiration through the catheter via the three ports. Total procedure time was measured as time required from positioning of the USG probe on the patient to successful blood aspiration from the catheter ports excluding time needed for suturing and dressing of the puncture site. Ease of catheterization was assessed by observing the above-mentioned time parameters.

Likert's scale was also assessed. A score of 1–5 is given depending on the ability to localize the vein and ease of catheterization. A score of 1 is given in case neither the vein is localized nor catheterization is possible and a score of 5 indicates an excellent view and easy catheterization (Table 1).

The diameter of the subclavian vein was measured as the distance between the anterior and posterior margin of the vein in a longitudinal view in both approaches. A single attempt was defined as when blood was aspirated via needle on the very first attempt without withdrawing the needle while advancing. When the needle insertion required more than three attempts was counted as multiple attempts. Any patient requiring multiple attempts was considered a failure and was excluded from the study. The right IJV was cannulated in such patients. Skin-to-subclavian vein depth, the diameter of the subclavian vein, attempt number, Likert's scale for ease of guidewire introduction, number of attempts, success rate, and any complications during and after the procedure were noted.

After recovery from anesthesia, the patient was then shifted to post anesthetic care unit (PACU). Postoperative chest X-ray anteroposterior (AP) or posteroanterior (PA) view was done to evaluate the position of the catheter tip and to rule out malposition and complications related to the procedure.[15]

Table 1: Likert's scale

Likert's score	*Localization of vein and ease of catheterization*
Score 1	Vein is not localized and catheterization is not possible
Score 2	The vein is localized but difficult to catheterization
Score 3	View is appropriate but a search for a better view is required in order to catheterize
Score 4	Good view found and will not search for another view. Catheterization is done comfortably
Score 5	Excellent view found and catheterization is easy

Statistical Analysis

After calculations, 20 patients in each study group was the minimum sample size requirement with 99% power of the study and a 5% level of significance. To decrease the margin of error, the total sample size taken was 60 (30 patients were recruited in each group). The data was recorded in as MS EXCEL spreadsheet, thereafter analysis was done using the licensed Statistical Package for Social Sciences (SPSS) latest version software. We compared quantitative variables using unpaired *t*-test/Mann-Whitney test (when the data sets had skewed distributed) between the two groups and qualitative variables were compared using the Chi-square test/Fisher's exact test.

Results

Demographic variables such as age, gender, weight, height, BMI and ASA physical status among the two groups showed no significant difference. Table 2 shows demographic variables among the two groups.

We reported the mean visualization time of subclavian vein for group SC as 17.97 ± 3.88 seconds whereas for group IC was 31.67 ± 6.2 seconds ($p < 0.001$). The mean puncture time for group SC was 101.17 ± 33.78 seconds and for group IC is 130.97 ± 44.27 seconds ($p = 0.005$). The mean catheter insertion time was higher for group IC 186.73 ± 33.97 seconds in comparison to group SC 154 ± 27.7 seconds ($p < 0.001$). In our study, the mean total procedure time for group SC was 270.77 ± 57.25 seconds, and for group IC was 349.47 ± 78.2 seconds ($p < 0.001$). These results are illustrated (Table 3). Figure 1 shows a graphical representation of time parameters involved in catheterization.

The mean depth of the subclavian vein from the skin in group SC was 17.20 ± 4.10 mm in comparison to group IC with a mean depth of 20.90 ± 4.92 mm ($p < 0.001$) (Table 4). Also, we reported that the mean diameter of the subclavian vein in group SC was 10.97 ± 1.40 mm, and in group IC was 9.05 ± 1.45 mm $p < 0.001$ (Table 3).

Table 2: Demographic variables of the study participants

	Supraclavicular group		*Infraclavicular group*		
Parameter (in years)	*Mean N = 30*	*SD*	*Mean N = 30*	*SD*	*p*
Age (in years)	41.40	13.265	39.97	13.843	0.684
Weight (in kg)	65.60	11.81	65.03	13.21	0.862
Height (in cm)	1.65	0.089	1.6457	0.083	0.688
BMI	23.99	4.31	23.97	4.99	0.983
ASA-I	12		10		0.861
ASA-II	12		13		0.861
ASA-III	6		7		0.861

We achieved a 100% overall success rate in both approaches through the use of real-time USG (RTUS) guidance throughout the procedure. The success rate for the first attempt was greater in group SC, i.e. 93.3 vs 80% than in group IC. A total of six patients in the infra clavicular group required a second attempt for successful cannulation as compared to two patients in group SC ($p > 0.05$).

Moreover, we noted that better scores (scores 3, 4, and 5) were in more patients in group SC (93.3%) than in group IC (86.7%). This is shown in Figure 2.

Also, we witnessed fewer immediate complications (3.3%) with the supraclavicular approach than the infra clavicular approach (10%) including arterial puncture, hematoma formation (0 vs 3.3 %), and misplaced guidewire (1 vs 3).

No significant difference is observed in the ultrasound view score (Likert scale) between the groups ($p > 0.05$). This is shown in Figure 2. No cases of pneumothorax and hemothorax occurred in any of the patients in our study. We also documented one case of the misplaced catheter in group IC in spite of a trial of repositioning and replacement by a second prick.

Discussion

The results of our study suggest that the SC route for subclavian vein cannulation is better than the IC route with respect to less time required for visualization, puncture, and subsequent catheterization. Also, the SC approach was associated with a superior view obtained due to lesser distance from the skin and wider diameter as compared to the IC approach. The incidence of complications like difficult guidewire insertion and catheter malposition, arterial puncture, etc., were comparable in the two groups.

Various studies and systematic reviews have compared the safety and efficacy of catheterization of both SC with the IC approach.[12–14,16–21] Byon HJ et al. noted median puncture time in 98 children <3 years of age. The median puncture time for IC group was longer as compared to the SC group (48 vs 36 seconds) ($p = 0.02$).[22] Complications like multiple attempts and guidewire misplacements were also seen more in the IC group as compared to the SC group. Prasad R et al. conducted the study among 110 critically ill patients.[14] The total procedural time, puncture, and visualization time were significantly shorter in the SC group when compared to the IC group.[14] The first attempt success rate was greater in the SC group and complications like malposition were higher in the IC group. On the basis of these studies, it can be concluded that the SC approach is a suitable and preferable alternative to the traditional IC approach.

Ease of catheterization was assessed with the following parameters; Visualization time, puncture time, catheter insertion time, total procedure time, rating of best view obtained for subclavian vein using Likert scale, diameter of subclavian vein, skin to subclavian vein depth, attempt numbers, ease of guidewire introduction, and success rate.

The mean visualization time, puncture time, catheterization time, and total procedural time for the SC group were significantly shorter as compared to the infraclavicular group ($p < 0.05$). This could be attributed to the more superficial location of the vein in the SC approach, thereby, facilitating quicker entry. Also, in infra-clavicular approach, the needle travels a comparatively greater distance through the pectoralis muscle and encounters hindrance from the clavicle. This can make needling via ultrasound, technically, a more time-consuming procedure. In the present study, we observed longer puncture times as compared to previous studies, perhaps due to more number of patients with higher BMI >30 kg/m^2 in both the groups, more so in infraclavicular group. Similarly, catheter insertion time (186.73 vs 154 sec) and mean total procedural time (270 vs 349 sec) was also greater in the IC group in contrast with the SC group ($p < 0.001$). Higher catheter insertion

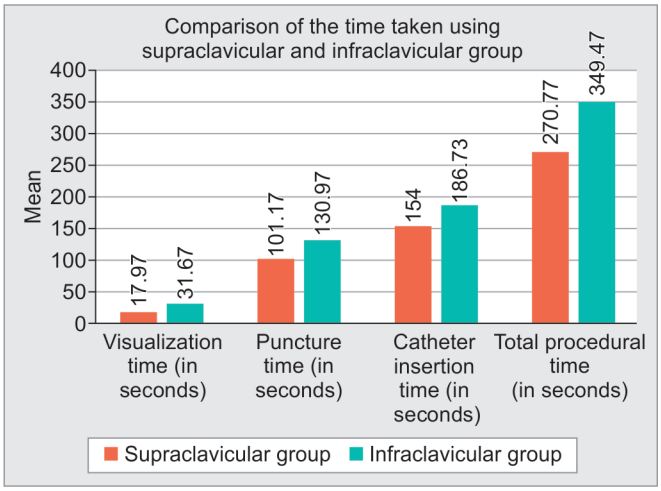

Fig. 1: Graphical representation of time parameters

Table 3: Comparison and testing difference in time taken (in seconds) between SC and IC groups

Parameter (in years)	*Supraclavicular group* *Mean* *N = 30*	*SD*	*Infraclavicular group* *Mean* *N = 30*	*SD*	*p*
Visualization time (in seconds)	17.97	3.882	31.67	6.266	0.000
Puncture time (in seconds)	101.17	33.782	130.97	44.271	0.005
Catheter insertion time (in seconds)	154.00	27.736	186.73	33.976	0.000
Total procedural time (in seconds)	270.77	57.250	349.47	78.236	0.000

Table 4: Comparison and testing of the significant difference in the depth of the subclavian vein from skin and diameter of the subclavian vein

Parameter (mm) *N = 30*	*Supraclavicular group* *Mean*	*Supraclavicular group* *SD*	*Infraclavicular group* *Mean*	*Infraclavicular group* *SD*	*p-value*
Depth of vein from skin (mm)	17.20	4.097	20.90	4.923	0.002
Depth of subclavian vein (mm)	10.97	1.40	9.05	1.45	0.000

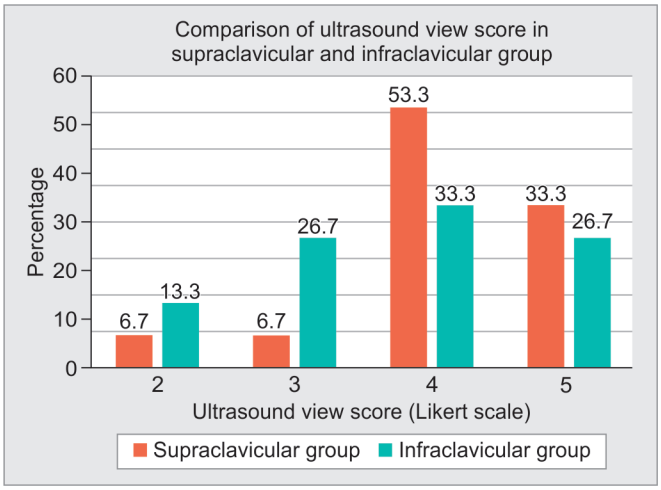

Fig. 2: Graphical representation of Likert scale for ultrasound view score

time could be related to the vicinity of the puncturing needle to the clavicle making guidewire introduction tricky. Bending of flexible guidewire while inserting catheters over guidewire was also commonly observed. Dense ligaments of the clavicle or the clavicle itself could have contributed to this problem. Additionally, guidewire confirmation took additional time in the IC approach as the probe had to be moved to other areas to rule out guidewire misplacement in ipsilateral IJV or brachiocephalic vein.

A number of patients with misplaced guidewire was more in the IC group in our study. The difference in needle position while performing the procedure might be responsible for this finding. The needle position in the SC approach is towards the heart while it is cephalad in the IC approach. The cephalad direction could lead to misplacement into the ipsilateral IJV in the IC approach while the possibility is lower in the SC approach. This could be potentially a detrimental complication as it would compromise cerebral venous drainage via IJV. Moreover, repositioning of the guidewire in the subclavian veins also took additional time in these patients, thereby, prolonging the overall time for catheterization.

The mean depth of the subclavian vein from the skin in group SC was significantly less in contrast with the IC group ($p < 0.001$). Scarcely any studies done previously have noted this parameter. We opine that a superior view would enhance the ability for successful cannulation.[23] Therefore, the SC route is liable to a superior view owing to superficial location of supraclavicular part of subclavin vein providing an additional anatomical benefit of using SC route.[2,8]

We observed that the success rate of the first attempt was greater in group SC–93.3 vs 80% in group IC. About six patients required a second attempt for successful cannulation in this group compared to 2 patients in group SC. Though the intergroup difference was not significant statistically ($p > 0.05$), it is significant clinically. We found the IC approach technically more challenging due to the various anatomical and patient factors described above. The proximity of the clavicle to the subclavian vein is not only a hindrance in obtaining a longitudinal view on ultrasound but also leads to difficult insertion of guidewire in the IC approach leading to a lower first attempt success rate.[14] Also, we found more misplaced guidewire in group IC, which called for repositioning/replacement thus a second attempt was made resulting in a higher number of second attempts. Higher difficult guidewire insertion was noticed in IC group (13.3%) than in the SC group (6.7%) ($p > 0.05$). Supraclavicular approach offers a short and more aligned path to the subclavian vein leading to easier guidewire insertion, whereas the clavicle was commonly encountered while positioning the guidewire in the IC approach.[12,14]

We also noted better Likert's scores (scores 3, 4, and 5) in more patients in group SC (93.3%) than in group IC (86.7%). We did not find a score 1 in either of the group (Table 1). Though this difference was not established to be significant statistically, nevertheless, it is clinically relevant while performing the procedure. Similar results were reported by Stachura MR et al.,[24] where they scanned USG images of the subclavian veins by both approaches in 98 patients where all patients went through scanning by both approaches. The authors found that the mean score for the right SC was higher at 4.06 vs 3.07 in the IC group. They found that 88.8% of the patients had higher scores in the SC group in comparison to 64.3% in group IC.

We witnessed that arterial puncture was more commonly encountered in group IC (10%) than group SC (3.3%), though it was not statistically significant Arterial puncture was often seen in patients with high BMI having poor USG view score and was more so with IC approach. We came across 2 cases of hematoma formation in group IC and none in group SC, which was statistically non-significant. This could be due to the deeper location and ineffective compression pressure exerted over the subclavian artery due to the close proximity of the clavicle. No case of pneumothorax or hemothorax was reported in either group. In our study, we diagnosed 1 patient of group SC and 3 patients of group IC with guidewire misplacement into ipsilateral IJV, during the procedure while scanning nearby vessels like ipsilateral IJV and brachiocephalic veins for confirmation of accurate guidewire position.[25]

There are numerous limitations to our study. Firstly, it was a single-center study with a small sample size, thereby, affecting the transferability of results. Also, since all patients in the study were euvolemic, the study results could not be extrapolated to hypovolemic patients. Thirdly, this study was performed among mechanically ventilated patients, so the results would, perhaps differ for spontaneously breathing patients. Lastly, the anesthetist performing the procedure was not blinded to the group allocations due to the nature of the study leading to bias.

Conclusion

To conclude, the results of our study indicate that the supraclavicular approach is more beneficial in terms of ease of catheterization and lesser immediate complications. In view of the emerging literature, it should be preferred over the conventional IC approach.

Clinical Significance

The present study has revealed that SC approach of subclavian vein cannulation is better than IC approach in terms of ease and efficiency of cannulation.

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