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Comparison of Subclavian Vein Catheterization Using Supraclavicular Versus Infraclavicular Approach with Ultrasound

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Abstract

Background: Infraclavicular (IC) approach for Subclavian Vein (SCV) catheterization is widely used compared to Supraclavicular (SC) approach. Recently, SC approach for SCV catheterization has gained prominence because of its well-defined landmarks with more success and less complication rate. The primary aim of this study is to determine whether US guided SC approach or IC, provides the best SCV catheterization and the complications related to either approach. *Methodology:* A total of 110 patients were randomly divided into two groups of 55 patients each, the SC group (Group S) and IC group (Group I). All SCV catheterization were done by single trained anesthesiologist. The parameters recorded were access time, successful catheterization, number of attempts, catheter insertion time, ease of guide wire insertion and complications. *Results:* Mean access time in Group S was 32.4s compared to 39.24s in Group I. Successful catheterization and numbers of attempts were better in SC approach. Mean catheterization time was 55.4 ± 3.02s in Group S and 78.3 ± 8.605s in Group I and was significant ($p < 0.0001$). 96.4% patients in Group S and 92.7% patients in Group I was successfully catheterized and was associated with smooth insertion of guide wire. There were two cases of arterial puncture and one case of hemotoma in Group I as compared to only one case of hemotoma in Group S. *Conclusion:* SVC cannulation by US guided SC approach is better with respect to IC approach in terms of time for catheterization and complications.

Keywords: Central venous catheterization; Subclavian vein catheterization; Supraclavicular; Infraclavicular.

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Introduction

In modern day anesthesia, Central Venous Catheterization (CVC) is a mandatory for various purposes like volume resuscitation, CVP monitoring, transvenous cardiac pacing, Hemodialysis, in cancer patients with difficult venous access and for chemotherapy. There are mainly three large venous routes of central line insertion namely the internal jugular, subclavian or femoral veins, each with its own advantages, disadvantages and potential complications.[1]

SCV is the most preferred alternative to internal jugular vein for central venous catheterization,[2,3] because of a lower-risk of infection as compared with internal jugular or femoral sites, easy placement in immobilized severely traumatic patients, less interference while endotracheal

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intubation, mechanical ventilation during Cardiopulmonary Cerebral Resuscitation (CPCR) and less patient discomfort for long-term intravenous treatment.[4] It also carries a lower risk of thrombosis when compared to femoral or internal jugular vein cannulation.[5,6] Because of the close proximity of the vulnerable anatomic structures (subclavian artery and lungs), SCV catheterization can result in complications such as subclavian artery puncture causing hemotoma, hemothorax and pneumothorax.[3,8,9] Ultrasound is the gold standard of care for central venous catheterization. The benefit includes an increase success rate, great efficiency and decreased complications.[9] In a review of strategies to improve patient safety the agency for healthcare research and quality in the United States identified ultrasound guidance during CVC insertion as one of 11 risk reduction strategies unequivocally supported by evidence.[10,11] US guidance for CVL placement in the internal jugular and femoral veins has been the focus of numerous studies.[12] Less studies have assessed the use of US guidance for the placement of SCV.[13] This may be related to the overlying clavicle, which partly restricts the sonographic view.

SCV can be cannulated by supraclavicular and infraclavicular approaches. SCV are routinely cannulated by IC landmark technique. With US guidance sound waves are obscured by bony structures in infraclavicular but clear with supraclavicular approach.[14] To our knowledge, there are limited studies which have reported on US guidance for the SC approach. Therefore, this study was undertaken to compare the ultrasound guided IC and SC approach regarding access time, number of attempts, catheter insertion time, ease of guide wire insertion and complications related to either approach.

Materials and Methods

This prospective randomized comparative study was undertaken after approval of Institutional Research and Ethics committee. Written informed consent was obtained from patients requiring cannulation. Patients were randomized into two groups of 55 each, i.e. Group S and Group I, by computer generated random number table. The study population consists of 110 ASA Grading I, II, or III of either sex scheduled for elective and emergency procedure requiring central venous catheterization and patients requiring long-term management in ICU. Patients with ASA Grade > IV, local infection at puncture site, trauma to clavicle, upper thoracic region, cervical spine, deranged coagulation profile, morbidly obese patients, distorted anatomy of the neck and mentally retarded patients were excluded from the study.

Following detailed examination, Patients who fulfilled the required criteria were taken for the study. 18G IV line was secured. Routine monitors like ECG, NIBP, SpO_2 were connected and baseline vital parameters were noted.

Central venous catheterization of SCV was done by using Seldinger's technique using triple lumen 7 Fr cannula. Ultrasound machine (Phillips HD7) equipped with high resolution of 3–11 MHz, linear transducer was used.

In all patients the right SCV was selected. The patients were in supine position and head turned towards the left side. SCV was catheterized using Seldinger's technique using US guidance. Chest *X*-ray was done after the procedure to confirm the position of the catheter and rule out complications.

Following parameters were taken into consideration to measure the efficacy of either approach:

Access time was defined as the time from initial skin puncture to the aspiration of blood from SCV through the needle;

The number of attempts was defined as the number, required for each needle advance to puncture the vein. More than three attempts were considered as failure for the study purpose;

Catheter insertion time was defined as time from blood aspiration through the needle to free aspiration from the catheter;

Ease of guide wire insertion-smooth or failed;

All times are measured in seconds;

Successful catheterization – was confirmed by chest *X*-ray;

Complications like pneumothorax, hemothorax, arterial puncture were recorded and treated appropriately. Patients were followed up for 24 hours.

Statistical Analysis

Fragou M et al.[15] in their a study in 2011 comparing US guided subclavian vein cannulation and landmark guided technique and found the mean access time to be 26 ± 12.8. We used this to calculate the sample size. Taking into consideration power of the study 80% and confidence interval as 95% (α = 0.05), the sample size was calculated to be 52 in each group, to detect a difference in access time of atleast 8s based on the study done by Byon et al., where they found the difference in median puncture time to be 8s. To allow for dropouts, 55 pts. were included

in each group.[17] Numerical values are presented as mean and standard deviations for continuous data whereas as categorical data is represented as frequencies and percentages. Unpaired *t*-test is applied for comparing numeric parameters like access time, puncture time, number of attempts, and catheter insertion time. All data will be analyzed with SPSS-20, $p < 0.05$ was considered significant.

Results

The demographic data were comparable in both the groups. The mean access time in Group S was 32.4s compared to 39.24s in Group I which is statistically significant ($p < 0.0001$). Total number of patients successfully catheterized in Group S (53 out of 55) is much better than in Group I (51 out of 55), but difference was not statistically significant ($p = 0.6787$). Complications like hemotoma only seen in one patient in Group S and arterial puncture in two patients, catheter malposition in one patient and hematoma in one patient is seen in Group I, were treated appropriately. Mean catheter insertion time was 55.4 ± 3.02s in Group S compared to 78.3 ± 8.605s in Group I, which is highly significant ($p < 0.0001$). All successful catheterization, i.e., 53 (96.4%) patients. in Group S and 51 (92.7%) patients in Group I, were associated with smooth insertion of guidewire following subclavian vein puncture. This difference was not statistically significant (p 0.6787) (Table 1).

Table 1: Outcome measures in Group S and Group I

Parameters	Group S	Group I	*p* - value	Remarks
Mean access time (seconds)	32.4 ± 2.868	39.24 ± 7.17	< 0.0001	Significant
Successful Catheterization	53 (96.4%)	51 (92.7%)	0.6787	Not significant
No. of Attempts				Not significant
1st attempt	45 (81.8%)	42 (76.4%)		
2nd attempt	8 (14.6%)	9 (16.3%)	0.66	
Failed	2 (3.6%)	4 (7.3%)		
Complications				
Arterial puncture	0	2		
Catheter malposition	0	1		
Hemotoma	1	1		
Catheter insertion time (seconds)	55.4 ± 3.02	78.3 ± 8.605	< 0.0001	Significant
Ease of Guide wire Insertion	53 (96.4%)	51 (92.7%)	0.6787	Not significant

Discussion

In our study, in order to overcome the various access approaches, patient position, technique and individual expertise the procedure was conducted by the same anesthesiologist for either approach. The demographic profiles were comparable in both the group.

The access time is an important step in the process of catheterization, once the needle is in the vein the other steps usually follows most of the time. In the study of Raphael PO et al., the mean puncture time (access time) was significantly lower in the US guided SC group (39.86 ± 9.80s) when compared to US guided IC Group (54 ± 10.56s) with $p < 0.0001$.[20]

Fragou M et al., study showed US guided average access time was significantly reduced than the landmark guided for CVC ($p < 0.05$).[15]

Byon et al, also showed access time was significantly less in SC Group compared to IC Group.[17]

Similar results were also found in the study of Thakur A et al. while comparing SC and IC approaches by landmark technique.[16]

Our result also concurs with the above studies. This significant difference in SC and IC can attributed to the anatomical proximity of the vein to the clavicle and difficulty in getting the longitudinal visualization because of the acoustic shadow of the clavicle as reported in the Byon et al.[17] As far as successful catheterization and number of attempts are concerned, SC approach is better than IC approach but this was found to be statistically nonsignificant in our study.

Similar results were found in the study of Thakur A et al.[16] Kores et al. observed overall success of 97% in the SC and 94% in the IC approach. First attempt

success in the SC group was 73% as compared to 68% in the IC approach.[18]

Sterner et al. (n = 255) documented an overall success rate of 84.5% in Group SC and 80% in Group IC.[19]

Fragou M et al., study showed US guided success rate was 100% and landmark guided was 87.5%. Average number of attempts in US guided was 1.1 ± 0.3 (1.1–1.5) (n = 200) and in landmark guided was 1.9 ± 0.7 (1.5–2.7) (n = 201), which was significant ($p < 0.05$).[15]

Our results does not correlate from the study of Fragou M et al., may be because of the difference in sample size. Mean catheterization time in our study was 55.4 ± 3.02s in Group S and 78.3 ± 8.605s in Group-I, which was significant statistically ($p < 0.0001$).

Similar results were found in a study by Raphael et al., mean catheter insertion time was significantly shorter in SC Group (120.29 ± 8.61s) when compared to IC Group (132.29 ± 6.51s) with $p < 0.01$.[20]

Byon et al., also found similar results in their study.[17] In our study, all successful catheterization, i.e., 96.4% patients in Group S and 92.7% patients in Group I, guidewire and catheter insertion was found smooth with no resistance encountered at any step, which was nonsignificant. This was similar to Kores et al., they did not have difficulty in threading the guidewire.[18] Complications associated with subclavian venous catheter placement are pneumothorax, hemothorax, subclavian artery puncture and hematoma at the puncture site.

In Byon HJ et al., study incidence of guidewire misplacement was higher in IC than SC (20.4% *vs* 0%, $p = 0.001$).[17] Hussain S et al. in their study found complication rates were higher in SC Group, but the difference was not statistically significant.[21]

Palepu GB et al. in their study, the impact of USG on CVC catheterization found complications rates 14.3% for landmark technique and 11.4% for US guided technique. The age, sex and the operator adjusted odds ratio for complication was 0.9 (95% CI: 0.16–5.0; p = 1) for USG when compared to landmark technique.[22] This is in contrast with the established facts that USG reduces complications.

Bras P et al., in Cochrane database systematic review analysis of the available data suggested 2D US improves some but not all aspects of effectiveness of CVC catheterization.[23]

Complications in our study did not have any sequele. These results must be viewed with caution taking various factors into consideration like the sample size, power of study, operator experience, approach and technique. Further trials required with largest sample size with adequate experience and well-defined technique (in plane or out of plane approach) will help to decide the superiority of one technique over the other.

Conclusion

SCV catheterization by US guided SC approach has faster access time, shorter catheter insertion time and lesser complications as compared to US guided IC approach.

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