

Comparative study of internal jugular, supraclavicular, and infraclavicular approaches for ultrasound-guided central venous catheterization

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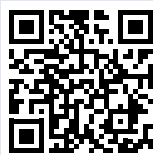


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ABSTRACT

Background and aims : Central venous catheterization is a widely used technique in the management of critically ill patients. Ultrasound-guided central venous catheterization has been shown to reduce complications and improve success rates. The internal jugular vein and subclavian vein are common access sites for central venous cannulation. In this study, we aim to compare these approaches in ultrasound-guided central venous catheterization.

Methods: A prospective comparative study was conducted at a teaching hospital between August 2022 and January 2023. The study included adult patients requiring central venous catheterization for various indications. Participants were randomly allocated to one of three groups: internal jugular, supraclavicular, or infraclavicular approach. Puncture time, catheter insertion time, guidewire insertion time, success rates, number of attempts, guidewire misplacement, and complications were recorded.

Results: The study comprised 143 patients, and there were no significant differences observed between the groups in terms of demographic characteristics. Mean puncture time and catheter insertion time were significantly shorter in the internal jugular group than in the other two groups. There were no significant differences in guidewire insertion time and success rates between the three groups. There were also no significant differences in complications or guidewire misplacement rates between the groups.

Conclusion: In ultrasound-guided central venous catheterization, the internal jugular approach had a shorter puncture time and catheter insertion time than the supraclavicular and infraclavicular approaches, with no significant differences in guidewire insertion time, success rates, complications, or guidewire misplacement rates. Internal jugular approach may be the preferred approach for ultrasound-guided central venous catheterization.

Keywords: central venous catheterization, internal jugular vein, subclavian vein, ultrasound guidance.

INTRODUCTION

Central venous catheterization (CVC) is an important technique that is commonly used for diagnostic and therapeutic purposes in intensive care and perioperative management. Ultrasound guidance for central venous catheterization has become the standard of care.^{1,2} This is due to a decrease in the number of insertion attempts, time to cannulation, and complications of central venous catheterization.³⁻⁶ Moreover, when using ultrasound to place a central venous catheter, the physician has a choice of ways to use ultrasound to visualize the target vessel during catheter placement.

The internal jugular vein (IJV) is frequently preferred as the access site for central venous cannulation due to several advantages. These include its superficial location, easy visualization with ultrasound, and a direct pathway to the superior vena cava (on the right side). The utilization of ultrasound enhances the success rate and reduces complications associated with accessing the IJV.⁶ The subclavian vein (SCV) has been recognized as a crucial vessel for central venous cannulation.⁵ Compared to other common sites for central venous access, SCV cannulation offers several advantages. These advantages include a reduced risk of thrombosis and infectious complications, improved patient comfort, and better preservation of patency during hypovolemic states.^{7,8} However, SCV cannulation is not without its complications, such as catheter malposition, arterial puncture, hematoma, pneumothorax, hemothorax, and nerve injury. Fortunately, recent studies have indicated that the use of ultrasonographic guidance can help mitigate

these complications.^{9,10} Accessing the subclavian vein can be achieved through either the supraclavicular or infraclavicular approach.¹¹ Therefore, this study contributes valuable insights into the various approaches of ultrasonography-guided central venous access, further enhancing our existing knowledge in this area.

METHODS

A prospective, comparative study was conducted to evaluate and compare the internal jugular, supraclavicular, and infraclavicular approaches for ultrasound-guided central venous catheterization (CVC). The study adhered to the ethical principles outlined in the Declaration of Helsinki and approval from the institutional ethics committee was obtained for this study. Prior to enrolment, all participants provided written and informed consent. The study data was treated confidentially and utilized solely for research purposes.

The study was conducted at Birat medical college teaching hospital from August 2022 to January 2023. The study included adult patients admitted to the Intensive care unit (aged ≥ 18 years) who require CVC for various indication. Patients with severe coagulation disorders (INR > 1.5 , platelets $< 100000/\text{cu mm}$), skin infection at the puncture site, emergency need for venous access, and previous central venous access were excluded from the study. The sample size for this study was calculated based on a pilot study of 20 central venous catheterization cases. With a confidence interval of 95% and power of 90%, the required sample size was determined to be at least 129, with at least 43 cases in each group.

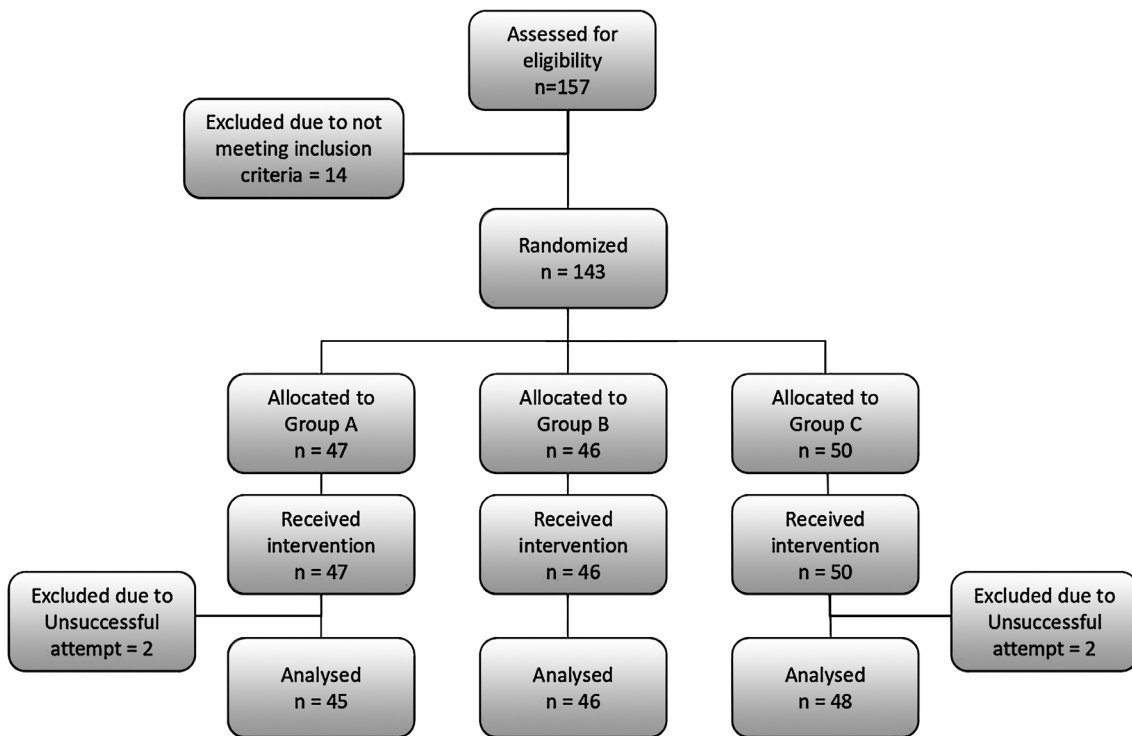


Figure 1: Consort flow chart (Group A: Internal jugular, Group B: Supraclavicular and Group C: Infraclavicular).

Participants were randomly allocated to one of the three groups using a computer-generated randomization sequence. The allocation sequences were concealed from the study investigators until the time of enrolment. All CVC procedures were performed by experienced anaesthesiologists who were proficient in all three approaches. The approach for each patient was randomly assigned. The procedures were performed under ultrasound guidance using SonoSite M-Turbo (Fujifilm SonoSite, Bothell, WA,) linear probe and a sterile technique. The patients were positioned in a supine position, and a 30-degree Trendelenburg position was maintained during the procedure. The internal jugular approach was performed using an out-of-plane view. The supraclavicular approach was performed using an in-plane view since the anatomy of supraclavicular fossa was not favourable for out-of-plane approach, while the infraclavicular approach utilized an out-of-plane approach. The puncture time, catheter insertion time, successful guidewire insertion in the first attempt, multiple attempts if any, and guidewire misplacement were recorded for each patient. Any complications such as pneumothorax, hemothorax, and arterial puncture were also documented.

In this study, several terms were defined for clarity. Puncture time referred to the duration between the initial skin puncture and the point at which blood was aspirated through the needle. The number of attempts represented the count of needle advances made to successfully puncture the vein. If more than three attempts were required, it was categorized as multiple attempts. Catheter insertion time denoted the time from blood aspiration through the needle to the point at which there was free aspiration through the catheter. Additionally, guidewire misplacement was defined as no verification or identification of the guidewire in either the brachiocephalic vein or the internal jugular vein.

Statistical analysis:

Descriptive statistics were used to summarize the demographic and clinical characteristics of the participants. Analysis of variance (ANOVA) was employed to compare continuous variables in the study. Categorical variables were compared using chi-square. Intergroup comparison was done using independent samples T-test. A p-value of <0.05 was considered statistically significant. All statistical analyses were performed using SPSS version 21.0 (IBM Corp., Armonk, NY, USA).

RESULTS

The study included a total of 143 participants, divided into three groups. In terms of demographic variables, there were no significant differences between the three groups in age, weight, height, and gender (Table 1). The puncture time, catheter insertion time, and total catheterization time were significantly shorter in the Internal Jugular group compared to the Supraclavicular and Infraclavicular groups ($p < 0.005$) (Table 2). The successful guidewire insertion rate was not statistically significant between the three groups ($p = 0.151$). However, the Infraclavicular group had a higher rate of multiple attempts and arterial punctures compared to the other two groups. There were no cases of guidewire misplacement in the Supraclavicular and Infraclavicular groups, while the Internal Jugular group had one case. The success rate and incidence of pneumothorax and hemothorax did not show significant differences between the three groups (Table 3).

Table 1: Demographic variables

Demographic variables		Groups			p-value
		Internal Jugular (mean±SD)	Supraclavicular (mean±SD)	Infraclavicular (mean±SD)	
Age (Years)		47.84 ± 19.35	43.65 ± 18.53	40.97 ± 16.4	0.189
Weight (Kgs)		66.48 ± 16.31	65.13 ± 15.01	61.45 ± 14.87	0.266
Height (cms)		157.6 ± 9.26	156.93 ± 9.52	157.56 ± 7.06	0.454
Gender	Male (n)	21	23	26	0.769
	Female (n)	24	23	22	

Table 2: Time characteristics (A: p-value comparing all three groups, B: p-value comparing Internal Jugular and Supraclavicular groups, C: p-value comparing Internal Jugular and Infraclavicular groups, D: p-value comparing Supraclavicular and Infraclavicular groups)

Time Characteristics (Seconds)	Groups			p-value			
	Internal Jugular (mean ± SD)	Supraclavicular (mean ± SD)	Infraclavicular (mean ± SD)	A	B	C	D
Puncture Time	23.46 ± 4.15	27.10 ± 3.60	36.95 ± 10.57	0.000	0.000	0.000	0.000
Catheter insertion time	30.51 ± 6.86	30.71 ± 6.99	38.25 ± 9.61	0.000	0.000	0.000	0.000
Total catheterization time	53.97 ± 8.12	57.82 ± 8.09	75.2 ± 13.38	0.000	0.026	0.000	0.000

Table 3: Complications and other variables

Other Variables	Groups			p - value
	Internal Jugular	Supraclavicular	Infraclavicular	
Successful guidewire insertion in the first attempt (n)	42	46	47	0.151
Multiple Attempts (n)	1	2	6	0.102
Guidewire misplacement (n)	1	0	0	0.349
Success rate (%)	95.6	100	97.1	0.360
Pneumothorax (n)	0	0	2	0.146
Hemothorax (n)	0	0	0	-
Arterial Puncture (n)	0	0	2	0.146

DISCUSSION

Various studies have compared the time characteristics, success rates, and complications of different approaches for central venous cannulation. The internal jugular vein approach was found to have a significantly shorter access time and total procedure time compared to infra-clavicular axillary vein cannulation in adult cardiac surgical patients.¹² The supraclavicular subclavian vein approach, infraclavicular subclavian vein approach, and internal jugular vein approach were found to have no significant differences in catheter insertion time, success rate, or complications during open-

chest cardiac surgery.¹³ The supraclavicular approach for ultrasound-guided right subclavian venous catheterization was found to have a significantly shorter time required for venous puncture compared to the infraclavicular approach, but catheter misplacements occurred more frequently in the infraclavicular group.¹⁴ Ultrasound-guided supraclavicular brachiocephalic catheterization and jugular vein catheterization were found to have no significant difference in success rate and mean cannulation time.¹¹ In a study comparing ultrasound-guided supraclavicular and

infraclavicular catheterization in children, the infraclavicular approach had a longer median puncture time and a significantly higher frequency of attempts greater than three, with a higher incidence of catheter misplacement.¹⁵ Our study found significant differences in mean puncture time and total procedure time among internal jugular, supraclavicular, and infraclavicular approaches, but comparable complications and success rates.

Based on the above observations, across different patient populations, the internal jugular approach is the superior approach in terms of shorter puncture time, catheter insertion time and total catheterization time, and low complications. The supraclavicular approach can be a reasonable alternative in specific patient populations.

There could be several factors that contribute to the differences observed in the studies. The anatomical location and characteristics of the targeted veins may play a role, as well as differences in the experience and technique of the operators performing the procedures. Additionally, variations in patient populations and underlying medical conditions may also have influenced the outcomes. Thus, it is important to carefully consider each approach according to the specific patient population when deciding which approach to use.

The present study has some limitations. Firstly, this was a single-center study with a relatively small sample size, which may limit the generalizability of the findings. Secondly, the study did not consider the clinical outcomes of the patients after catheterization such as infection and thrombosis, which are important considerations in the selection of an approach for central venous catheterization.

CONCLUSION

The results of this study suggest that the internal jugular approach may be superior to the supraclavicular and infraclavicular approaches for ultrasound-guided central venous catheterization in terms of puncture time, catheter insertion time, and total catheterization time. The infraclavicular approach had longer puncture and catheter insertion times and total catheterization time. However, the success rate and other complications were similar across all three approaches. Therefore, the internal jugular approach could be considered as the first-choice and supraclavicular approach is a reasonable alternative for ultrasound-guided central venous catheterization.

Further studies with larger sample sizes and involving operators with varying levels of experience are needed to confirm these findings and to determine the best approach for different patient populations.

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