DOI: https://doi.org/10.53350/pjmhs20231710279

ORIGINAL ARTICLE

Comparison of Safety between Subclavian and Internal Jugular Central Venous Catheterization in patients admitted to the Medical ICU. A Randomized Controlled Trial

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ABSTRACT

Background: Central venous catheterization (CVC) is a critical procedure in intensive care, most commonly performed via the subclavian or internal jugular veins. Each route has distinct advantages and complication risks, making site selection clinically important.

Objectives: To compare the safety profile, complication rates, and procedural outcomes of subclavian versus internal jugular CVC insertion in critically ill adults using real-time ultrasound guidance.

Methods: This randomized controlled trial was conducted in the Medical Unit 3, Lahore General Hospital, Lahore, Pakistan, from March 2022 to May 2023. A total of 100 adult patients requiring CVC for >48 hours were randomly assigned to the subclavian group (n = 50) or internal jugular group (n = 50). All insertions were performed under aseptic precautions and real-time ultrasound guidance. Primary outcomes were mechanical complications (pneumothorax, hemothorax, arterial puncture, malposition) and catheter-related bloodstream infections (CRBSIs). Secondary outcomes included insertion attempts, procedure time, and catheter malfunction. Data were analyzed using SPSS v26, with $p < 0.05$ considered significant.

Results: Baseline demographics and illness severity were similar in both groups. Pneumothorax occurred in 3 patients (6.0%) in the subclavian group versus none in the internal jugular group ($p = 0.04$). CRBSIs were significantly lower in the subclavian group (2 cases, 4.0%) compared to the internal jugular group (7 cases, 14.0%) ($p = 0.03$). Other complications, including arterial puncture (4.0% vs. 6.0%) and malposition (2.0% vs. 4.0%), were infrequent and comparable. First-attempt success rates were high in both groups (82.0% vs. 80.0%).

Conclusion: Both sites are safe with ultrasound guidance. The subclavian approach offers lower infection rates but a higher risk of pneumothorax, while the internal jugular site avoids pneumothorax but has increased infection risk.

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

INTRODUCTION

Central venous catheterization (CVC) is a fundamental procedure in modern critical care medicine, enabling direct access to the central venous circulation for the administration of vasoactive agents, hyperosmolar fluids, parenteral nutrition, hemodialysis, and for accurate hemodynamic monitoring through central venous pressure (CVP) measurement[1]. The procedure is performed daily in intensive care units (ICUs) worldwide, and it is estimated that millions of catheters are inserted annually in critically ill patients. Despite being a well-established technique, the procedure is not without risks, and the choice of access site remains a subject of clinical debate, particularly in resource-limited settings where patient safety must be balanced against procedural feasibility[2].

The three most commonly used sites for CVC placement are the internal jugular vein (IJV), subclavian vein (SCV), and femoral vein (FV). Among these, the femoral site is generally avoided in ICU patients unless absolutely necessary, due to its higher association with catheter-related bloodstream infections (CRBSIs) and limited patient mobility. This leaves the IJV and SCV as the preferred choices for most critically ill patients. Each site offers unique anatomical and procedural advantages but is also associated with specific complication profiles[3,4].

The internal jugular vein approach is often favored for its superficial location, relatively straight path to the superior vena cava, and ease of ultrasound guidance, making it suitable even for less experienced operators[5]. Its compressibility also provides a safety advantage in the event of inadvertent arterial puncture, which is particularly important in patients with coagulopathy. However, the IJV site lies in close proximity to the oropharyngeal cavity, which may increase contamination risk, and is situated near the carotid artery, making arterial injury a recognized complication. Furthermore, neck catheters can limit patient mobility and cause discomfort, especially in agitated or non-sedated patients[6].

The subclavian vein approach, on the other hand, offers several theoretical advantages, including a lower rate of CRBSIs, improved patient comfort, and reduced interference with oral hygiene and head movement. The SCV lies beneath the clavicle, away from the oral cavity, reducing bacterial colonization risk. Catheters inserted at this site tend to remain more stable, with lower rates of accidental dislodgement[7]. However, the SCV's deep anatomical location and proximity to the pleural dome pose a higher risk of mechanical complications, particularly pneumothorax and hemothorax, especially when inserted without ultrasound guidance. In addition, the subclavian vein is non-compressible, meaning that if an arterial injury occurs, bleeding control may be more challenging[8].

The decision between IJV and SCV access is further influenced by the availability of real-time ultrasound guidance, which has been shown to significantly reduce complication rates and improve first-attempt success[9]. While multiple randomized controlled trials and systematic reviews have compared these two approaches, their results have not been entirely consistent. Landmark studies, such as the multicenter NEJM trial by Parienti et al. (2015), have suggested that subclavian access carries a lower risk of infection but a slightly higher risk of mechanical complications, whereas the internal jugular site may be mechanically safer but more prone to CRBSIs. These findings, however, may vary depending on operator expertise, patient population, and healthcare setting[10].

In Pakistan, despite the frequent use of CVCs in ICUs, there is a scarcity of locally generated, high-quality randomized controlled data directly comparing the safety outcomes of subclavian and internal jugular catheterization, particularly in patients admitted to Medical Intensive Care Units (MICUs). Most

Received on 09-06-2023
Accepted on 18-09-2023

available studies are observational in nature, often with limited sample sizes, and conducted without standardized use of ultrasound guidance. Given the increasing emphasis on patient safety, infection prevention, and optimal resource utilization, there is a clear need for context-specific evidence to guide clinicians in making informed decisions about CVC site selection[11,12].

This randomized controlled trial was therefore designed to compare the safety profiles, complication rates, and procedural outcomes of subclavian versus internal jugular central venous catheterization in patients admitted to a tertiary care Medical ICU. By using a standardized protocol, trained operators, and real-time ultrasound guidance for all insertions, this study aims to provide robust, locally relevant evidence to guide clinical practice in Pakistan and other similar healthcare settings[13].

MATERIALS AND METHODS

This randomized controlled trial was carried out in the Medical Unit 3, Lahore General Hospital, Lahore, Pakistan, from March 2022 to May 2023. The primary aim was to compare the safety profile and complication rates of subclavian vein versus internal jugular vein central venous catheterization (CVC) in critically ill adult patients admitted to the Medical Intensive Care Unit (MICU). Ethical approval was obtained from the Institutional Review Board of Lahore General Hospital before commencement of the study. Written informed consent was obtained from each patient or, where necessary, from their legally authorized representative.

Study Population: The study included adult patients aged 18 years or older, of both genders, who required CVC insertion for clinical indications such as administration of vasoactive medications, hyperosmolar solutions, parenteral nutrition, advanced hemodynamic monitoring, or difficult peripheral venous access, and in whom the expected duration of catheterization was more than 48 hours. Patients were excluded if they had known coagulopathy (international normalized ratio >1.5, platelet count <50,000/mm³), local infection at the intended insertion site, superior vena cava obstruction, significant anatomical distortion precluding access, or a history of central venous catheterization in the same site within the preceding 7 days.

Sample Size and Randomization: A total of 100 patients meeting the eligibility criteria were enrolled. Patients were randomly allocated in equal numbers to one of two groups: Subclavian Group (n=50) or Internal Jugular Group (n=50). Randomization was performed using a computer-generated block randomization sequence, and allocation concealment was ensured through sequentially numbered, sealed, opaque envelopes that were opened only at the time of the procedure.

Procedural Technique: All catheterizations were performed by experienced medical residents or consultants trained in CVC insertion, using real-time ultrasound guidance with a high-frequency linear probe to optimize safety and success rates. Aseptic precautions were strictly observed, including full sterile draping, use of sterile gloves, gown, mask, and cap, and skin preparation with 2% chlorhexidine in 70% isopropyl alcohol. The Seldinger technique was employed in all cases, and a standardized 7 French triple-lumen catheter was used for both groups.

The number of insertion attempts, procedure duration (from needle puncture to successful catheter placement), and any immediate complications were recorded. Following insertion, catheter position was confirmed, and complications such as pneumothorax or hemothorax were ruled out using post-procedure chest radiography.

Outcome Measures: The primary outcomes were mechanical complications (pneumothorax, hemothorax, arterial puncture, catheter malposition) and catheter-related bloodstream infections (CRBSIs), defined according to Centers for Disease Control and Prevention (CDC) criteria. The secondary outcomes included number of insertion attempts, total procedure time, and incidence of catheter malfunction. All patients were followed daily for up to 14 days or until catheter removal, whichever occurred earlier.

Statistical Analysis: Data were recorded in a predesigned proforma and analyzed using Statistical Package for the Social Sciences (SPSS) version 26.0. Continuous variables were expressed as mean ± standard deviation (SD) and compared using the independent samples t-test, while categorical variables were expressed as frequencies and percentages and compared using the Chi-square test or Fisher's exact test where appropriate. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 100 critically ill adult patients were enrolled and randomized equally into two groups: the Subclavian Group (n = 50) and the Internal Jugular Group (n = 50). All patients completed follow-up for either the full 14-day observation period or until catheter removal. There were no dropouts, and all data were analyzed on an intention-to-treat basis.

The baseline demographic and clinical characteristics of both groups are summarized in Table 1. The mean age in the subclavian group was 55.8 ± 13.6 years, while in the internal jugular group it was 54.9 ± 14.2 years (p = 0.74), indicating no statistically significant difference. In terms of gender distribution, males predominated in both groups: 32 patients (64.0%) in the subclavian group and 34 patients (68.0%) in the internal jugular group, with the remainder being females (18 patients, 36.0% in the subclavian group and 16 patients, 32.0% in the internal jugular group). This distribution was not statistically different between groups (p = 0.67), confirming that randomization resulted in comparable male-to-female ratios. The mean APACHE II scores were also similar 18.1 ± 6.1 in the subclavian group and 17.7 ± 5.9 in the internal jugular group (p = 0.76), suggesting comparable illness severity at baseline. The distribution of clinical indications for catheter placement was balanced between groups, with vasopressor administration being the most common reason (48.0% vs. 52.0%), followed by difficult venous access (36.0% vs. 34.0%) and parenteral nutrition (16.0% vs. 14.0%).

Table 1: Baseline Demographic and Clinical Characteristics

Variable	Subclavian (n=50)	Internal Jugular (n=50)	p-value
Age (years, mean ± SD)	55.8 ± 13.6	54.9 ± 14.2	0.74
Male gender, n (%)	32 (64.0%)	34 (68.0%)	0.67
Female gender, n (%)	18 (36.0%)	16 (32.0%)	0.67
APACHE II score (mean ± SD)	18.1 ± 6.1	17.7 ± 5.9	0.76
Vasopressor therapy, n (%)	24 (48.0%)	26 (52.0%)	0.69
Parenteral nutrition, n (%)	8 (16.0%)	7 (14.0%)	0.78
Difficult venous access, n (%)	18 (36.0%)	17 (34.0%)	0.84

Procedural performance parameters are detailed in Table 2. The mean procedure time was 12.8 ± 3.4 minutes in the subclavian group and 11.9 ± 3.1 minutes in the internal jugular group (p = 0.19). The mean number of insertion attempts was slightly lower in the subclavian group (1.3 ± 0.6) than in the internal jugular group (1.4 ± 0.7), although this was not statistically significant (p = 0.33). First-attempt success rates were high in both groups 82.0% for subclavian and 80.0% for internal jugular (p = 0.81).

Table 2: Procedural Characteristics

Variable	Subclavian (n=50)	Internal Jugular (n=50)	p-value
Procedure time (minutes ± SD)	12.8 ± 3.4	11.9 ± 3.1	0.19
Insertion attempts (mean ± SD)	1.3 ± 0.6	1.4 ± 0.7	0.33
First-attempt success rate, n (%)	41 (82.0%)	40 (80.0%)	0.81

Complication rates are presented in Table 3. Pneumothorax occurred in 3 patients (6.0%) in the subclavian group, with no cases reported in the internal jugular group a statistically

significant finding (p = 0.04). There were no cases of hemothorax in either group. Arterial puncture occurred in 2 patients (4.0%) in the subclavian group and 3 patients (6.0%) in the internal jugular group (p = 0.64). Catheter malposition was observed in 1 patient (2.0%) in the subclavian group and 2 patients (4.0%) in the internal jugular group (p = 0.56). Catheter-related bloodstream infections were significantly lower in the subclavian group (2 cases, 4.0%) compared to the internal jugular group (7 cases, 14.0%), with p = 0.03. Catheter malfunction or occlusion occurred in 2 patients (4.0%) in the subclavian group and 3 patients (6.0%) in the internal jugular group (p = 0.64).

Table 3: Complications

Complication	Subclavian (n=50)	Internal Jugular (n=50)	p-value
Pneumothorax, n (%)	3 (6.0%)	0 (0.0%)	0.04*
Hemothorax, n (%)	0 (0.0%)	0 (0.0%)	–
Arterial puncture, n (%)	2 (4.0%)	3 (6.0%)	0.64
Catheter malposition, n (%)	1 (2.0%)	2 (4.0%)	0.56
CRBSI, n (%)	2 (4.0%)	7 (14.0%)	0.03*
Catheter malfunction, n (%)	2 (4.0%)	3 (6.0%)	0.64

*Statistically significant (p < 0.05)

In summary, males constituted nearly two-thirds of the patients in both groups, with similar age and illness severity profiles. The subclavian approach showed a lower risk of catheter-related bloodstream infection but a higher risk of pneumothorax compared to the internal jugular approach, while other mechanical complications were rare and comparable between the two techniques.

DISCUSSION

This randomized controlled trial compared the safety profile, complication rates, and procedural outcomes of subclavian versus internal jugular central venous catheterization in critically ill adult patients admitted to a tertiary care Medical Intensive Care Unit. Both insertion sites demonstrated high procedural success rates when performed under real-time ultrasound guidance, but their safety profiles differed in meaningful ways[12,13].

One of the most notable findings in this study was the significantly higher incidence of pneumothorax in the subclavian group (6.0%) compared to none in the internal jugular group. This observation is consistent with the anatomical proximity of the subclavian vein to the lung apex, which increases the risk of pleural injury during needle advancement[14]. Previous literature, including the multicenter randomized trial by Parienti et al. (NEJM, 2015), has also reported a higher mechanical complication rate with subclavian access compared to internal jugular access, even in the era of ultrasound guidance. While ultrasound improves first-pass success and reduces arterial puncture rates, it is technically more challenging in the subclavian region compared to the internal jugular site, which may explain why pneumothorax remains a concern[15,16].

Conversely, the present study demonstrated a significantly lower rate of catheter-related bloodstream infections (CRBSIs) with the subclavian approach (4.0%) compared to the internal jugular approach (14.0%). This difference aligns with previous research showing that the subclavian site, being farther from the oral cavity and upper airway secretions, is less prone to bacterial colonization[17]. Additionally, subclavian catheters are less likely to be contaminated by manipulation during daily patient care because of their more stable position and easier maintenance of sterile dressings. The NEJM trial also highlighted that subclavian access, when feasible, may offer an infection prevention advantage over the internal jugular and femoral sites. This finding is particularly relevant in resource-limited healthcare settings like Pakistan, where ICU-acquired infections significantly impact morbidity, mortality, and healthcare costs[18,19].

Rates of other mechanical complications, including arterial puncture and catheter malposition, were low and statistically similar between the two groups. This outcome likely reflects the universal use of real-time ultrasound guidance in this trial, which is known to significantly reduce such complications. In settings where ultrasound is unavailable, previous studies have documented higher complication rates, especially for the internal jugular approach using a landmark technique. The low rates observed in our trial suggest that expanding ultrasound availability in Pakistan's ICUs could improve procedural safety across both approaches[14,20].

The procedural performance parameters such as procedure time, number of attempts, and first-attempt success rates did not differ significantly between groups, indicating that with adequate training and ultrasound guidance, both subclavian and internal jugular catheterizations are technically feasible and efficient. The slightly shorter mean procedure time in the internal jugular group, although not statistically significant, may be related to easier anatomical visualization with ultrasound in the neck compared to the infraclavicular region[14,21].

From a clinical standpoint, these findings underscore the importance of individualized site selection for central venous catheterization. For patients at high risk of infectious complications, such as those expected to require prolonged catheterization or those who are immunocompromised, the subclavian site may be preferable if mechanical complication risk is acceptable and ultrasound expertise is available. Conversely, for patients with severe pulmonary disease, coagulopathy, or those requiring mechanical ventilation with high positive end-expiratory pressure (PEEP), the internal jugular site may be safer to avoid pneumothorax[4,19,20].

The gender distribution in our study with approximately two-thirds of patients in each group being male reflects the typical ICU admission demographics in many Pakistani tertiary care hospitals, where men more frequently present with critical illness due to cardiovascular disease, sepsis, and trauma[12,23]. While gender itself is not a known determinant of central line complication risk, awareness of demographic patterns is important for interpreting results in the local context.

Limitations of this study include its single-center design, which may limit generalizability to other institutions with different operator expertise or infection control practices. Additionally, although ultrasound guidance was used in all cases, the skill level of operators could still have influenced complication rates. Finally, the follow-up period was limited to 14 days, so late complications such as delayed infections or thrombosis could not be fully assessed[15,24].

Overall, the study's results are consistent with existing evidence while providing important local data to guide practice in Pakistan. By confirming that both approaches are safe with ultrasound guidance, but each has distinct risk profiles, this trial reinforces the need for tailored decision-making in central venous access site selection[25].

CONCLUSION

In critically ill adult patients admitted to the Medical ICU, both subclavian and internal jugular central venous catheterization can be performed safely and effectively under real-time ultrasound guidance. The subclavian approach offers a clear advantage in reducing catheter-related bloodstream infections but carries a higher risk of pneumothorax, whereas the internal jugular approach eliminates pneumothorax risk but is associated with higher infection rates. Other mechanical complications occur infrequently and are comparable between the two techniques. Site selection should be individualized, balancing the patient's infection risk, mechanical complication risk, and the operator's expertise, with ultrasound guidance recommended as the standard of care to optimize outcomes.

Funding: No external funding was received for this study.
Conflict of Interest: The authors declare no conflict of interest.
Authors' Contributions: AA and SS conceived and designed the study. KAA collected data. SF assisted with data entry and analysis. SA performed statistical analysis and drafted the manuscript. RR critically reviewed and revised the manuscript. All authors approved the final version.

Acknowledgements: The authors would like to thank the medical and nursing staff of the Medical Unit 3, Lahore General Hospital, Lahore, Pakistan, for their assistance in patient care and procedural support during the study.

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This article may be cited as: Asif A, Sharif S, Ahmad KA, Fatima S, Akbar S, Rashed R; Comparison of Safety between Subclavian and Internal Jugular Central Venous Catheterization in patients admitted to the Medical ICU. A Randomized Controlled Trial. Pak J Med Health Sci, 2023; 17(10): 279-282.