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Comparisona Of Sono Anatomy Of Medial Oblique Axis View And Short Axis View In Ultrasound Guided Central Venous Catheter Placement Of Right Internal Jugular Vein- A Randomised Controlled Study

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Abstract
Introduction: *This randomized controlled trial compared two ultrasound probe positions, the short axis and the medial oblique axis, for internal jugular vein (IJV) catheterization. The study evaluated the sono anatomy of the IJV relative to the carotid artery (CA), as well as the safety of each technique by measuring first-pass success rate, number of needle attempts, and complications.*
Methods: *Patients undergoing ultrasound-guided IJV catheterization were randomized into two groups. Measurements of the IJV's transverse diameter and the CA's position (medial, postero-medial, or posterior) were taken using both the short axis and medial oblique views. First-pass success rate and the number of needle attempts were recorded for each technique. Statistical analysis was performed to compare the two methods.*
Results: *The medial oblique axis view yielded a significantly larger mean transverse diameter for the IJV (2.08±0.092 cm) compared to the short axis view (1.69±0.13 cm; p<0.005). The medial oblique view also showed a higher prevalence of the CA in the postero-medial position. The first-pass success rate was significantly greater in the medial oblique group (86.7%) compared to the short axis group (p=0.001), and the number of needle attempts was substantially lower (1.13±0.34 vs. 1.7±0.79; p=0.001).*
Conclusion: *The medial oblique axis view is superior to the short axis view for ultrasound-guided IJV catheterization. This technique provides a better anatomical view, leading to a greater first-pass success rate and fewer needle attempts. These findings support the medial oblique view as the optimal method for central venous catheterization, reducing the risk of complications such as unintentional carotid artery puncture.*
Key words: *Ultrasound-guided catheterization, Right internal jugular vein (IJV), Short axis view, Medial oblique axis, Needle insertion technique, Vascular access.*

INTRODUCTION:

Central venous catheterization (CVC) is a widely used technique for administering medications, monitoring central venous pressure, and providing vascular access in critically ill and perioperative patients.[1] [2] While various access sites are available, the right internal jugular vein (IJV) is a favored route due to its direct and predictable path to the right atrium and its accessibility for compression in patients with bleeding diatheses.[3] Traditionally, CVC placement has relied on the landmark technique,[4] which is associated with a notable first-pass failure rate (31%) and a risk of complications, including arterial puncture (5%) and hematoma.[5]
The introduction of ultrasound (US) guidance in the 1980s has significantly improved the safety and efficacy of IJV catheterization.[6] US allows for real-time visualization of anatomical structures, confirming vein patency

and reducing the risk of accidental arterial puncture and other complications.[7] Two primary US-guided approaches are commonly used: the short axis (out-of-plane) and the long axis (in-plane) views. The short axis view provides a comprehensive cross-sectional image of the vein and surrounding structures, which is ideal for avoiding arterial puncture. Conversely, the long axis view allows for continuous visualization of the needle's entire trajectory, minimizing the risk of posterior vessel wall penetration.
The medial oblique axis approach combines the benefits of both techniques, providing a simultaneous view of the IJV and the carotid artery (CA) while allowing the needle to be tracked from the skin to the vessel. This hybrid technique aims to optimize the needle's trajectory and reduce the risk of inadvertent CA puncture. While previous studies have compared the landmark technique to US guidance and the short axis to the long axis view, a direct comparison of the medial oblique axis and short axis views is limited. This study aims to bridge this gap by comparing the sono anatomy and safety of the US-guided medial oblique and short axis probe positions, focusing on first-pass success rate, number of needle attempts, and potential complications.

AIMS AND OBJECTIVES

A. Primary objective: To compare the sono anatomy of the Medial oblique axis and Short axis ultrasound approaches for IJV catheterisation with regard to the following parameters:

1. Transverse diameter of IJV
2. Anteroposterior diameter of IJV
3. Percentage overlap of IJV over carotid artery
4. Relative position of carotid artery to IJV

B. Secondary objective: To compare the safety and efficiency of the Medial oblique axis and Short axis ultrasound approaches for IJV catheterisation with regard to the following parameters:

1. First-pass success rate
2. Number of attempts
3. Time for guidewire placement
4. Time for catheter placement
5. Total duration of catheterization

Incidence of complications (e.g., carotid artery puncture, pneumothorax, hemorrhage, and hematoma formation)

MATERIALS AND METHODS

Study Design and Population

This study was a randomized controlled trial conducted over 18 months at a single institution, involving 60 patients aged 18 to 65 years. The participants were scheduled for either elective or emergency major surgeries requiring right internal jugular vein (IJV) catheterization. Patients were assigned to one of two groups (30 per group) using a computer-generated randomization list delivered in opaque, sealed envelopes to ensure allocation concealment.

Group M [M-OAX]: Ultrasound-guided IJV catheterization was performed using the medial oblique axis approach.

Group S [SAX]: Ultrasound-guided IJV catheterization was performed using the short axis approach.

Inclusion and Exclusion Criteria

Patients of both sexes with an ASA physical status of I to IV were included. Exclusion criteria comprised patient refusal, pregnancy, coagulation abnormalities (platelet count <100,000/μL), a history of previous neck surgery, and the presence of a right-sided neck swelling.

Sample Size Calculation

The sample size was determined based on a pilot study involving five patients per group, using the formula:[8] [9]

$$n=(Z1-\alpha/2 + Z1-\beta)^2\ 2S^2/D^2$$

With a 5% alpha level of significance ($Z1-\alpha/2 = 1.96$) and 80% power ($Z1-\beta = 0.842$), and based on a mean difference in insertion time (D=5.2 seconds) and a pooled standard deviation (S=10.0 seconds) from the pilot data, the calculated sample size was 58.06. A final sample size of 60 patients, 30 per group, was chosen to account for potential dropouts.

Data Collection

Following institutional ethical committee approval, all selected patients underwent a comprehensive pre-anesthetic evaluation. Detailed information about the procedure was provided, and written informed consent was obtained. The catheterization procedures were performed by experienced staff and senior residents from the Department of Anesthesiology.

Procedure

Following general anesthesia induction and endotracheal intubation, patients were placed in a 15-degree Trendelenburg position with the head turned 15 degrees to the left. Aseptic precautions were strictly maintained. A linear ultrasound probe (13-6 MHz) was positioned between the sternal and clavicular heads of the sternocleidomastoid muscle at the level of the cricoid cartilage.

In Group S (SAX), the probe was placed in a transverse orientation to obtain a short axis, out-of-plane view of the IJV. The anteroposterior and transverse diameters of the IJV were measured, and the percentage of IJV overlap on the carotid artery (CA) was calculated. The needle was then inserted perpendicularly to the probe's long axis.

Figure 1: Sono anatomy of Short axis view

A. Transverse diameter of IJV
B. Anteroposterior diameter of IJV
C. Length of IJV overlapping CA

Figure 2: Sono anatomy of Medial Oblique axis view

A. Transverse diameter of IJV
B. Anteroposterior diameter of IJV
C. Length of IJV overlapping CA

In Group M (M-OAX), the probe was rotated approximately 30 degrees counterclockwise from the short axis view to achieve a medial oblique axis. This in-plane approach allowed for continuous visualization of the needle from the skin puncture point to its entry into the vein. The IJV's anteroposterior and transverse diameters and its overlap with the CA were also measured.

In both groups, successful venous access was confirmed by the visual indentation of the anterior vein wall and subsequent blood aspiration. The Seldinger technique was used to advance the guidewire and catheter. A single unblinded observer recorded key procedural metrics, including first-pass success, the number of attempts, and the time for guidewire and catheter placement. The occurrence of complications such as carotid artery puncture, pneumothorax, and hematoma was also noted.

Statistical Analysis

All collected data were analyzed using SPSS for Windows, version 28. Continuous variables were presented as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. The significance of continuous data was evaluated using Student's t-test, and categorical data were analyzed with the Chi-square test. A p-value of < 0.05 was considered statistically significant.

RESUlts

Analysis of the results, as detailed in the four accompanying tables, demonstrated that the two patient groups were statistically homogeneous with respect to age, gender, and ASA physical status (Table 1), confirming the success of the randomization process. Key findings emerged from the sonographic anatomical and procedural comparisons.

Table 1: Patient Demographic and ASA Physical Status

Parameter	**Group S [SAX] Short axis (n=30)**	**Group M [M-OAX] Medial oblique (n=30)**	**Total (N=60)**	**p-value**
Age (years)				0.198
Mean ± SD	44.20±13.70	48.40±11.17	46.30±12.57	
Gender				0.774
Male	22 (73.3%)	21 (70.0%)	43 (71.7%)	
Female	8 (26.7%)	9 (30.0%)	17 (28.3%)	
ASA Grade				0.629
I	10 (33.3%)	13 (43.3%)	23 (38.3%)	
II	15 (50.0%)	14 (46.7%)	29 (48.3%)	
III	5 (16.7%)	3 (10.0%)	8 (13.3%)	

Sonographic evaluation of the internal jugular vein (IJV) revealed a significantly larger mean transverse diameter in the medial oblique axis view (2.08±0.092 cm) compared to the short axis view (1.69±0.13 cm, p<0.005). Critically, the medial oblique axis also showed a marked reduction in the percentage of IJV overlap with the carotid artery (CA) (26.27±10.67%) compared to the short axis view (48.18±13.54%, p=0.000). Furthermore, the medial oblique view indicated a greater prevalence of the postero-medial CA position (93.3%) relative to the IJV, which was significantly different from the short axis group (76.7%, p=0.009) (Table 2).

Table 2: Comparison of Sonoanatomy of IJV

Parameter	**Group S [SAX] Short Axis**	**Group M [M-OAX] Medial Oblique Axis**	**p-value**
Transverse Diameter of IJV (cm)	1.69±0.13	2.08±0.092	<0.005

Anterior Diameter of IJV (cm)	1.04±0.098	1.00±0.094	0.103
Length of IJV Overlapping CA (cm)	0.81±0.23	0.54±0.21	0.000
Percentage Overlap of IJV over CA (%)	48.18±13.54	26.27±10.67	0.000
Position of CA in Relation to IJV			0.009
Medial	0 (0.0%)	2 (6.7%)	
Posterior	7 (23.3%)	0 (0.0%)	
Postero-medial	23 (76.7%)	28 (93.3%)	

These anatomical advantages translated into superior procedural outcomes. The medial oblique axis technique yielded a significantly higher first-pass success rate (86.7%) compared to the short axis approach (46.7%, p=0.001). This was mirrored by a statistically significant reduction in the mean number of needle attempts (1.13±0.34) compared to the short axis group (1.70±0.79, p=0.001). Consequently, the medial oblique method resulted in a substantially shorter mean total catheterization duration (195.06±22.40 seconds) compared to the short axis method (236.66±53.28 seconds, p=0.000) (Table 3).

Table 3: Comparison of Procedural Outcomes

Parameter	Group S [SAX] Short Axis	Group M [M-OAX] Medial Oblique Axis	p-value
First-Pass Success Rate			0.001
No (%)	16 (53.3%)	4 (13.3%)	
Yes (%)	14 (46.7%)	26 (86.7%)	
Number of Needle Attempts (Mean ± SD)	1.70±0.79	1.13±0.34	0.001
Time to Guide-wire Placement (seconds)	92.90±43.21	52.33±16.26	0.001
Time to Catheter Placement (seconds)	57.33±13.38	50.53±5.22	0.012
Total Catheterization Duration (seconds)	236.66±53.28	195.06±22.40	0.000

Regarding complications, the overall incidence was low. Although not statistically significant (p=0.103), the medial oblique axis group exhibited a trend toward a lower rate of carotid artery puncture (n=1) compared to the short axis group (n=6). There were no cases of pneumothorax or hemothorax in either group, and hematoma formation was observed exclusively in the short axis group (n=3) (Table 4). These results collectively indicate that the medial oblique axis view provides enhanced anatomical clarity and superior procedural safety, efficiency, and success compared to the short axis approach.

Table 4: Comparison of Complications

Complication	Group SAX (n=30)	Group M-OAX (n=30)	p-value
Carotid Artery Puncture	6	1	0.103
Hematoma	3	0	0.237
Pneumothorax	0	0	1.000
Hemothorax	0	0	1.000

DISCUSSION

The traditional anatomical landmark-based approach for internal jugular venous (IJV) catheterization carries a documented risk of significant complications, including carotid artery puncture, hematoma, and pneumothorax.[10] These risks are amplified in patients with challenging anatomical features, such as a short neck or altered anatomy,[11] where successful cannulation often requires multiple needle attempts.[12] The widespread adoption of ultrasound guidance has fundamentally advanced this procedure, providing real-time visualization of the vessels and needle trajectory, thereby substantially mitigating these risks and improving first-pass success rates.[13] [14] Our study builds upon this foundation by directly comparing the medial oblique axis view, a more advanced sonographic technique, against the established short axis view to evaluate differences in anatomical visualization, procedural efficacy, and safety.[15]

Our sonographic anatomical findings provide strong evidence for the advantages of the medial oblique axis view. Consistent with the findings of Baidya et al., [16] the present study demonstrated that the mean transverse diameter of the IJV was significantly larger when visualized in the medial oblique axis view (2.08±0.092 cm) compared to the short axis view (1.69±0.13 cm, $p<0.005$). This observation suggests that the medial oblique view may offer a more accurate depiction of the vein's true size, which can facilitate more precise needle targeting. Crucially, we also found a statistically significant reduction in the percentage of IJV overlap with the common carotid artery (CCA) in the medial oblique axis view (26.27±10.67%) compared to the short axis view (48.18±13.54%, p=0.000). This reduced overlap creates a clearer anatomical separation between the two vessels, which is a critical safety advantage that minimizes the risk of inadvertent arterial puncture.

Interestingly, our findings on the positional relationship between the CA and IJV differed from those of previous research. We observed a much higher prevalence of the postero-medial position for the CA in both the short axis (76.7%) and medial oblique axis (93.3%) views than reported in the literature. These variations underscore the importance of patient-specific ultrasound assessment, as anatomical relationships may vary between populations and necessitate a tailored approach to needle guidance.

The anatomical benefits of the medial oblique view translated into superior procedural outcomes. Our data revealed a significantly higher first-pass success rate in the medial oblique axis group (86.7%) compared to the short axis group (46.7%, p=0.001). Furthermore, the medial oblique approach required significantly fewer needle attempts (1.13±0.34) and resulted in a substantially shorter mean total catheterization duration (195.06±22.40 seconds) compared to the short axis approach (236.66±53.28 seconds). While the time for catheter placement itself was not significantly different between the groups, the overall procedural time savings were driven by the enhanced efficiency of the initial vascular access steps. These findings are consistent with the improved visualization and alignment offered by the medial oblique view, which allows for a more direct and efficient needle trajectory.

Regarding complications, while the overall incidence was low, the medial oblique axis group showed a trend toward a lower rate of carotid artery puncture and hematoma formation. These findings, although not statistically significant in this study, align with the anatomical advantages observed and suggest a safer procedural profile. In conclusion, our findings demonstrate that the medial oblique axis view is a superior technique for ultrasound-guided IJV catheterization, offering enhanced anatomical clarity, higher first-pass success, and greater procedural efficiency compared to the traditional short axis approach.

Limitations

A primary limitation of this study is the relatively small sample size, which may constrain the generalizability of our findings to a broader population. The single-center design further limits the applicability of these results to other clinical settings and demographic groups. Future multi-center studies with larger, more diverse cohorts are needed to validate our findings. Additionally, we acknowledge that the study did not account for all potential confounding variables, such as operator experience or pre-existing patient comorbidities that could influence procedural outcomes.

CONCLUSION

In conclusion, our study provides compelling evidence that the medial oblique axis view is superior to the conventional short axis view for ultrasound-guided internal jugular venous catheterization. This technique offers enhanced anatomical visualization, characterized by a more accurate representation of the vein's transverse diameter and a greater separation from the carotid artery, thereby significantly improving procedural safety. These advantages translated into superior clinical outcomes, including a substantially higher first-pass success rate and a significant reduction in the number of needle attempts. While our findings on the relative positioning of the carotid artery differed from some previous studies, they highlight the importance of patient-specific anatomical assessment. Our data support the adoption of the medial oblique axis as a more effective, efficient, and safer technique. Further large-scale, multi-center research is warranted to validate these findings and establish this approach as the new standard of care.

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