Original Article

DOI: 10.7860/JCDR/2024/69660.19532

Anaesthesia Section

Comparison of Three Different Approaches to Ultrasound Guided Internal Jugular Vein Cannulation: A Randomised Clinical Study

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ABSTRACT

Introduction: The standard approaches to ultrasound-guided central line insertion by Short Axis (SAX) and Long Axis (LAX) have limitations. The Medial Oblique Axis (M-OAX) approach allows visualisation of the length of the needle in real-time along with both the artery and vein.

Aim: To compare the three approaches for ultrasound-guided right Internal Jugular Vein (IJV) cannulation with respect to ease of access and complications.

Materials and Methods: A total of 171 patients scheduled to undergo right IJV cannulation were divided equally into three groups-SAX (Group-1), LAX (Group-2), and M-OAX (Group-3). They were compared with respect to first pass success, Venous Access Time (VAT), guide wire insertion time, catheterisation time, and complications. Continuous variables were compared with Analysis of Variance (ANOVA) test. Categorical variables were analysed using the Chi-square test. The p-value <0.05 was considered significant.

Results: First pass success was 55 (96.49%), 53(92.98%), and 54 (94.74%) in groups 1, 2, and 3, respectively. The VAT, guidewire insertion time, and catheterisation time were significantly lesser in Groups 1 and 3 compared to 2 (p<0.001). Two cases of carotid artery puncture were noted in Group-2, though statistically not significant (p>0.05).

Conclusion: The medial oblique approach to IJV cannulation combines the advantages of both LAX and SAX and is a safer alternative with easier and faster venous access.

Keywords: Carotid artery, Central venous catheterisation, Ultrasonography

INTRODUCTION

The IJV cannulation is an invasive procedure, often carried out in the Intensive Care Unit (ICU) and in the peri-operative period. Its suitable anatomical location and lower infection rate make IJV a very popular site for central venous access. Traditional approaches to IJV cannulation are based on anatomical landmarks, whereas the American Society of Anaesthesiologists' practice guidelines for central venous access recommend using real-time Ultrasonography (USG) guidance for IJV access [1]. Additionally, a study conducted by Karakitsos D et al., suggests that ultrasound-guided catheterisation of the IJV in intensive care patients is superior to the anatomical technique and is therefore recommended as the method of choice [2].

Two approaches commonly employed to view the IJV using ultrasound are LAX and SAX. The LAX approach guarantees visibility of the needle tip and the needle in its entirety. In the SAX approach, both the artery and vein are visualised simultaneously, but the entire length and tracking of the needle cannot be visualised and carries the risk of posterior wall puncture. A newer approach, M-OAX, combines the advantages of both, i.e., the ability to visualize the artery and vein in the same view as well as tracking the needle in real-time simultaneously, which can be useful for a novice anaesthesiologist [3]. Limited studies are available regarding the use of this approach, and there is a need to prove its utility and safety [1,3,4]. Thus, this study was conducted to compare three approaches, namely SAX, LAX, and M-OAX, for USG-guided IJV cannulation. The oblique view is obtained by first locating the vessel in the SAX, after which the probe is rotated to almost midway between the SAX and LAX views. With this technique, both the carotid artery and IJV are visualised in a slightly elongated view on the screen [5]. It was hypothesised that the M-OAX approach is safer and faster when compared to LAX and SAX approaches for IJV catheterisation under USG guidance. The primary objective was to compare the three approaches for ultrasound-guided right IJV cannulation in terms of first needle pass success. The secondary objectives were to compare the number of needle passes, VAT, guide wire insertion time, catheterisation time as well as the complications pertaining to the procedure.

MATERIALS AND METHODS

A prospective single-blinded randomised clinical study was conducted in the Department of Anaesthesiology and Critical Care Unit at a tertiary care hospital in Bangalore from March 2021 to October 2022 after obtaining Institutional Ethical Committee clearance (IEC Study Ref No. 386/2020). The study was registered at CTRI/2022/03/041082.

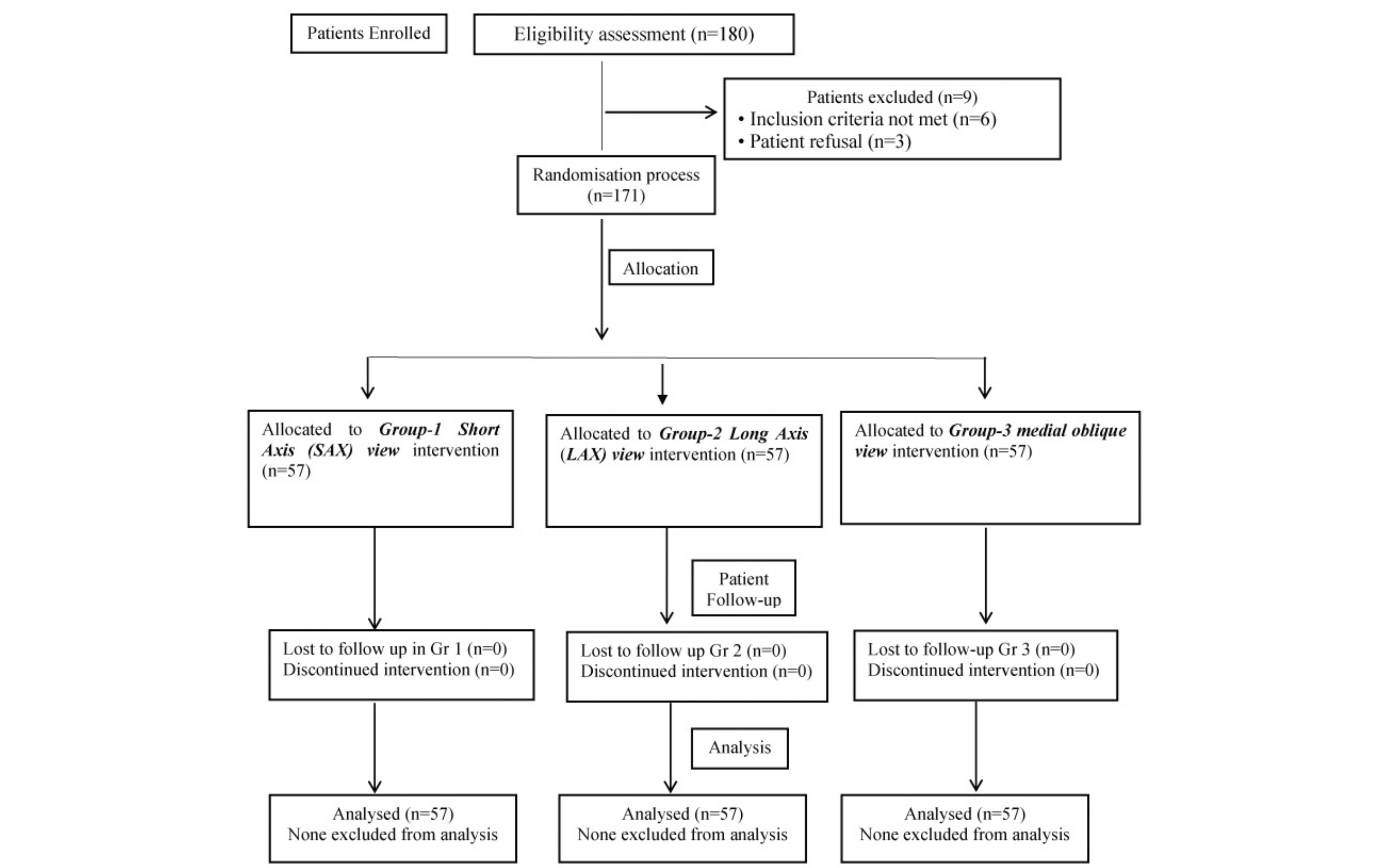
Inclusion criteria: Those patients aged between 18-70 years of either sex, posted for elective surgery or admitted to the critical care unit who required Central Venous Cannulation (CVC) were included in this study.

Exclusion criteria: Patients with an infection at the site of cannulation, subcutaneous haematoma at or close to the puncture site, recent cervical spine trauma, previous surgical procedures at the cannulation site, cervical spondylosis, coagulopathy (International Normalised Ratio (INR)>1.5, Platelet count <1 lac), and obese patients (BMI>30) were excluded from the study.

Sample size calculation: The sample size calculation was based on the study by Lal J et al., [4]. They reported a 19.4% point difference in the first pass success rate between M-OAX and LAX view, where M-OAX had a success rate of 97.2%. To observe a similar difference with 80% power and a 2.5% level of significance (Bonferroni adjustment for three group comparisons), a sample size of 57 per group was required.

Procedure

After obtaining written informed consent, 171 patients were included in this study and were divided into three groups (Group-1, 2, 3) by computer-generated randomisation. The SAX approach was used in Group-1 (n=57), the LAX approach in Group-2 (n=57), and the M-OAX approach in Group-3 (n=57) [Table/Fig-1]. In the



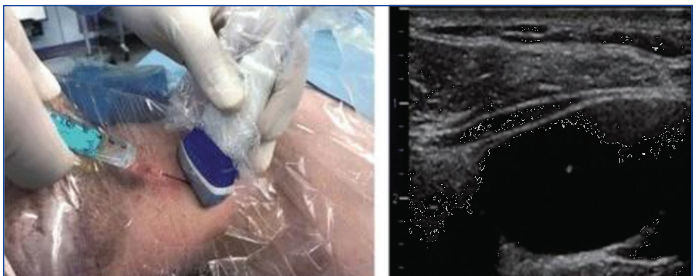
[Table/Fig-1]: CONSORT diagram.

operation theatre, standard monitors included Electrocardiography (ECG), SpO2, and Non-Invasive Blood Pressure (NIBP). Patients were intubated after the induction of general anaesthesia. Intubated patients from the ICU were also included in the study.

Subsequently, patients were placed in the Trendelenburg position with a 30° tilt. Ultrasound-guided IJV cannulations using the modified Seldinger technique were performed by an anaesthesiologist with experience of ≥20 procedures with a 7F (15 cm) triple-lumen catheter. The same operator handling the transducer also performed the vascular puncture while visualising the needle under ultrasound guidance. A high-frequency (6-13MHz) linear array transducer vascular probe of the Turbo Sonosite USG machine was used.

In the SAX approach, the transducer was placed transversely over the neck, superior and parallel to the clavicle at the level of the cricoid cartilage. Once the vein was visualised, the needle attached with a syringe was introduced with gentle aspiration. The needle tip was visualised as a white dot on the screen [Table/Fig-2]. In the LAX approach, the transducer was placed in a longitudinal axis over the neck, and once the vessels were identified, the needle was inserted in a cranio-caudad direction over the collapsible vein just underneath the footprint of the probe [Table/Fig-3].

In the M-OAX approach, after obtaining a SAX view of the vein, the transducer was rotated 30° counter-clockwise medial-cephalad to the lateral-caudal direction [Table/Fig-4] [6]. The needle was inserted and advanced in the plane of the ultrasound probe after vein identification. When the needle entered the vein as visualised on the ultrasound screen, venous blood was aspirated, and a guidewire was passed into the vein. The venous placement confirmation of the guidewire was done by visualising the guidewire in the lumen of the vein using USG, thereafter the needle was retracted. Continuous ECG monitoring was done to look for any arrhythmias. The tract was dilated, and the catheter was threaded over the guidewire following which the guidewire was removed. Backflow in all three ports was confirmed, and the catheter was



[Table/Fig-2]: Short Axis (SAX) approach.

[Table/Fig-3]: Long Axis (LAX) approach.

[Table/Fig-4]: Medial oblique approach.

secured with sutures. The catheter tip position was confirmed on a chest X-ray, and complications pertaining to the procedure per se were documented.

The following parameters were observed in the study:

Primary outcome:

- First needle pass success (yes/no)-considered successful upon aspiration of venous blood.

Secondary outcomes:

1. Number of needle passes-up to four needle passes were allowed, after which it was considered a failure, and an alternate technique was adopted.
2. Venous Access Time (VAT)-the time from the start of the insertion of the introducer needle to the return of venous blood.
3. Guide wire insertion time-the time from the start of the insertion of the needle until crossing the second marker of the guide wire.
4. Catheterisation time-the time from the start of the insertion of the needle until the placement of the catheter and confirmation of blood aspiration in the ports were noted.
5. Complications-Carotid artery puncture, haematoma formation, arrhythmias, pneumothorax, and haemothorax, if any, were noted.

STATISTICAL ANALYSIS

The Statistical Package for Social Sciences (SPSS) program, windows version 23.0, was used for statistical analysis. Continuous variables are presented as mean±SD, and categorical variables are depicted as absolute numbers and percentages. Continuous variables such as VAT, guide wire time, and catheterisation time, which are normally distributed, were compared using Analysis of Variance (ANOVA) test. The Chi-square test was used for the analysis of categorical variables. A p-value <0.05 was considered statistically significant.

RESULTS

The demographic data, including age, gender, and body mass index of the participants in all three groups, were comparable [Table/Fig-5]. The average age of the participants in all groups was over 50 years.

Demographic parameters	Group-1	Group-2	Group-3	p-value
Age (Years) Mean±SD	55.05±8.9	54.7±8.69	54.16±8.73	0.858
Gender (M/F)	30/27	35/22	25/32	0.172
BMI (kg/m²)	26.4±0.8	27.2±0.6	28.2±0.4	0.312

[Table/Fig-5]: Demographic profile of patients in Group-1,2,3.
Test of significance: Analysis of Variance (ANOVA) and Chi-square test

First pass success was observed in 55 (96.49%), 53 (92.98%), and 54 (94.74%) patients in Groups 1, 2, and 3, respectively, with a p-value of 0.703, indicating no statistically significant difference. The distribution of the number of needle passes among the three groups was similar. Significant differences were observed between the groups for mean VAT, guidewire time, and catheterisation time (p=0.001) [Table/Fig-6]. Both Group 1 and Group 3 had statistically significantly shorter VAT, guidewire insertion time, and catheterisation time compared to Group 2. There was no difference regarding guidewire insertion time and catheterisation time, but there was a significant difference in VAT between Group 1 and 3 (p<0.001). Pairwise comparisons of VAT, guidewire insertion time, and catheterisation time are shown in [Table/Fig-7].

There were two cases of carotid artery puncture (3.5%) seen in Group 2 and none in the other groups, which was not statistically significant (p-value=0.132). Other complications such as haematoma, haemothorax, and pneumothorax were not noted in any of the three groups [Table/Fig-8].

	Group-1 SAX	Group-2 LAX	Group-3 M-OAX	p-value ANOVA
First pass success	55 (96.49%)	53 (92.98%)	54 (94.74%)	0.703
Number of successful needle passes in N (%) (1st Attempt)	55 (96.49%)	53 (92.98%)	54 (94.74%)	0.703
Number of successful needle passes in N (%) (2nd Attempt)	2 (3.5%)	4 (7%)	3 (5.3%)	0.608
VAT (Seconds)	16.02±1.57	24.39±2.19	17.37±1.65	**0.001**
Guidewire insertion time (Seconds)	32.04±3.64	41.54±3.48	32.49±3.23	**0.001**
Catheterisation time (Seconds)	105.02±4.43	109.61±3.10	104.21±3.76	**0.001**

[Table/Fig-6]: Cannulation parameters among Group-1,2,3.
Test of significance: Analysis of Variance (ANOVA)

Group	Venous Access Time (VAT) p-value	Guidewire insertion p-value	Catheterisation time p-value
Group-1/2	**<0.001**	**<0.001**	**<0.001**
Group-2/3	**<0.001**	**<0.001**	**<0.001**
Group-3/1	**<0.001**	0.761	0.496

[Table/Fig-7]: Intergroup comparison.
p-value <0.05 significant; Test of significance: ANOVA

Complications	Group-1	Group-2	Group-3	p-value
Carotid artery puncture	0	2	0	0.132

[Table/Fig-8]: Complications.
Test of significance: Chi-square test

DISCUSSION

The study was conducted to evaluate the safety profile and ease of Internal Jugular Vein (IJV) cannulation using the M-OAX view compared to traditional approaches. The M-OAX view had a higher first pass success rate compared to the other approaches. Intergroup comparison between M-OAX and LAX showed statistically significant differences in terms of Venous Access Time (VAT), guidewire insertion time, and catheterisation time. Guidewire insertion time and catheterisation in M-OAX were comparable to the SAX approach, but VAT was not comparable. Therefore, the M-OAX view allows for faster venous access, which can be attributed to the ideal imaging of the IJV and carotid artery alongside and following the needle path until vessel penetration in a medial cephalad to lateral caudal direction.

Although the catheterisation time in the LAX group was longer compared to other groups, the difference was only a few seconds and hence not clinically significant. Therefore, it was concluded that the ease of cannulation was similar between the three groups. The American Society of Echocardiography and the Society of Cardiovascular Anaesthesiologists published recommendations in 2011 emphasising the need for ultrasound guidance during vascular access as most effective when used in real-time during needle advancement. The needle is observed on the screen and concurrently directed toward the target vessel, advanced to an appropriate depth, away from important surrounding structures [7]. Also, simultaneous visualisation of the artery and vein, along with real-time tracking of the needle, keeps a novice clinician more comfortable with the M-OAX approach compared to other approaches. The authors observed a higher first-pass success rate compared to similar studies [4,8-10], as they routinely use USG for central line insertion and are familiar with these approaches. The faster and easier access probably depends on the frequency of USG usage, user habituation, and comfort, which in turn may depend upon institutional protocols.

The first-pass success rate was higher in similar studies conducted by Lal J et al., and Kamalipour H et al., but was lower in the study

Sl. no.	Author's name and year	Place of study	Number of subjects	Approaches compared	Parameters assessed	Conclusions
	Lal J et al., 2020 [4]	Rohtak, Harayana	108	Short Axis (SAX), Long Axis (LAX) and Medial oblique	1st pass success rate, mean Venous Access Time (VAT), guidewire insertion time and catheterisation time	First pass success rate was highest in M-OAX, followed by SAX and LAX. Mean VAT, guidewire insertion time and catheterisation time were longest in LAX (p<0.05)
	Kamalipour H et al., 2015 [8]	Shiraz, IR Iran	80	SAX and M-OAX	First pass success, VAT, Catheterisation time	First attempt success was similar in M-OAX and in SAX group (p>0.05). Difference in VAT and catheterisation time in groups M-OAX and SAX were not statistically significant
	Batllori M et al., 2016 [9]	Pamplona, Spain	220	SAX, LAX and Medial oblique	first pass success, mean guidewire insertion time	Higher first pass success rate in M-OAX (73.6%) followed by SAX (69.9%) when compared to LAX (52%) (p<0.05) Guidewire insertion time was longest in LAX
	Balaban O et al., 2020 [10]	Kutahya, Turkey	82	SAX and Medial oblique	Mean number of needle puncture attempts, Mean guidewire insertion time	Mean number of needle puncture attempts: SAX-1.12±0.5,M-OAX-1.21±0.61 Mean time of guidewire insertion was significantly less in SAX group compared to oblique axis
	Baidya DK et al., [13]	All India Institute of Medical Sciences, New Delhi, India	200	SAX view and medial oblique view.	Needle tip visibility, Guide wire visibility, First insertion success rate for IJV puncture, VAT, incidence of posterior wall of IJV puncture and time to cannulation	Needle tip visibility was significantly higher during IJV puncture in medial oblique probe position (68 of 98 vs 40 of 99; p < 0.001). Guide wire was seen in significantly higher number patients where medial oblique probe position was used (59 of 98 vs 34 out of 99; p <0.001). Success rate for first insertion during IJV puncture, VAT and incidence of IJV posterior wall puncture and time to venous cannulation were similar.
	Present study	Bangalore, India	171	SAX, LAX and Medial oblique	1st pass success rate, mean VAT, guidewire insertion time and catheterisation time	The first pass success was observed in 55(96.49%), 53(92.98%) and 54(94.74%) in 1,2 and 3, respectively with p-value of 0.703, hence not statistically significant. The mean VAT, guidewire time and catheterisation time was 16.02±1.57 sec, 32.04±3.64 sec, 105.02±4.43 sec, respectively in Group-1; 24.39±2.19 sec, 41.54±3.48 sec and 109.61±3.10 sec, respectively in Group 2; 17.37±1.65 sec, 32.49±3.23 sec, 104.21±3.76 sec, respectively in Group-3. Group-1 and Group-3 had statistically significant shorter VAT, guidewire insertion time and catheterisation time when compared to Group-2. There were two cases of carotid artery puncture (3.5%) seen in Group-2 and none in other groups which was not statistically significant (p value= 0.132).

[Table/Fig-9]: Summary of similar studies [4,8-10,13].

conducted by Batllori M et al., [4,8,9]. The VAT, guidewire insertion time, and catheterisation time in the study conducted by Lal J et al., were similar to the present findings. Only the guidewire insertion time was compared between the three groups in the study conducted by Batllori M et al., and they found that it was longer in LAX compared to the other groups, which was similar to these findings. The catheterisation time was slightly lower in the SAX and M-OAX groups in the study conducted by Kamalipour H et al., compared to the present study. The guidewire insertion time in SAX and M-OAX in the study conducted by Balaban O et al., was comparable to this study [10]. The differences in the VAT and catheterisation time among the different studies could be due to familiarity with the USG machine and the approaches used. Difficulties in catheter insertion were also taken into account in the present study, unlike some studies where only the guidewire insertion time was compared. The novel technique of the M-OAX approach could be extrapolated to other sites of central venous insertion for easier access. Kurien M et al., compared three approaches, namely, the high (HA), conventional (CA), and the medial oblique approach (MA), to identify the best approach and head position for IJV cannulation. They also established and recommended that the medial oblique probe position with a 30° head rotation provides ideal real-time sonographic parameters for US-guided IJV cannulation [11].

Vascular injury, carotid arterial puncture, pseudo-aneurysm, haematoma formation, and venous air embolism are some of the complications associated with CVC insertion. The incidence of various complications ranges from 5 to 19% [12]. In the present study, two cases of carotid artery puncture were seen in the LAX group and none in the other groups. Haematoma, haemothorax, and pneumothorax were not encountered in any group. Carotid artery puncture was noted in two patients in the LAX group in the study conducted by Lal J et al., Haematoma and bleeding were noted in one patient in the M-OAX group and two patients in the SAX group in the study conducted by Balaban O et al., [4,10]. There was no increased incidence of complications in the M-OAX approach overall. Hence, the M-OAX view is a safe technique for IJV central venous catheter insertion. Similar studies from the literature have been compared in [Table/Fig-9] [4,8-10,13].

Limitation(s)

There is a likelihood of operator bias in the present study as it is not possible to blind the operator about the approach used for ultrasound-guided IJV insertion. This study cannot be extrapolated to the paediatric age group as there will be anatomical differences. The present study did not note the incidence of posterior wall puncture. Obese patients and those with cervical trauma were excluded from this study. Hence, challenges faced in these anatomical constraints need further investigation.

CONCLUSION(S)

Within the limitations of this study, it can be concluded that the M-OAX approach to USG-guided IJV cannulation had a higher first-pass success and faster catheterisation time when compared to traditional SAX and LAX approaches. It is also a safe technique. The advantages of both SAX and LAX are combined in the medial oblique access, making venous access easier and faster. It can be routinely included in our clinical practice.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: Jan 18, 2024
- Manual Googling: Feb 28, 2024
- iThenticate Software: Apr 10, 2024 (22%)

ETYMOLOGY: Author Origin

EMENDATIONS: 8

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. No

Date of Submission: **Jan 17, 2024**
Date of Peer Review: **Feb 26, 2024**
Date of Acceptance: **Apr 11, 2024**
Date of Publishing: **Jun 01, 2024**