

## Original Research Article

# Comparison of three different techniques for internal jugular vein cannulation under real time ultrasound guidance

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### ABSTRACT

**Background:** Ultrasound (USG) guided Internal jugular venous (IJV) cannulation is preferred than traditional approach due to increase in success rate, reduction in time taken and attempts of successful cannulation and less complications. The purpose of our study was to observe and compare three different real time 2-dimensional US-guided approaches and to determine which approach improves rate of successful cannulation, decreases complications along with shorter average time taken for the procedure. Primary outcomes of the study were venous access time, catheterization time and success rate. Secondary outcomes were number of patients requiring second attempt and complications observed.

**Methods:** 120 adult patients were randomly divided into three groups according to real time US guided cannulation done with SAX-OP approach, LAX-IP approach and OAX-IP approach. Parameters like venous access time, catheterization time, number of patients requiring second attempt and complications were noted.

**Results:** Venous access time was shortest in LAX group  $21.84 \pm 3.67$  seconds which was just significant statistically. Catheterization time was shortest in LAX group  $241 \pm 123$  seconds. Cannulation success rate was highest in LAX group 98% and was statistically significant. Patients requiring second attempt was least in LAX group 2.5%. Posterior IJV wall puncture was observed in 10% patients in SAX group and none in LAX and OAX group which was statistically significant.

**Conclusions:** LAX-IP showed better performance in terms of higher cannulation success, lesser average venous access time and catheterization time and lesser complications. On toggling USG probe, both IJV and carotid artery can be differentiated and carotid puncture could be avoided. Hence LAX approach is safer and effective approach.

**Keywords:** Technique, Axis, Vein, Cannulation

### INTRODUCTION

Internal jugular vein (IJV) catheterization is commonly attempted to obtain central venous access for hemodynamic monitoring, long term administration of fluids, antibiotics, total parenteral nutrition and hemodialysis.<sup>1</sup> Ultrasound (USG) guided internal jugular venous (IJV) cannulation is preferred than traditional approach/ landmark technique due to increase in success rate, reduction in time taken, decrease in number of attempts of successful cannulation and less

complications.<sup>2</sup> Real time ultrasound controlled vascular puncture is the gold standard of practice. Many approaches are used by different practitioners.<sup>3,4</sup> Short axis out of plane (SAX-OP) approach permits visualization of both artery and vein in same window however needle tip visualization and control may be difficult with this axis. So, more chances of needle going beyond the vessel. In long axis in plane (LAX-IP) approach, needle tip and path are better visualized, however short neck and other anatomical variations make US probe usage little difficult. Further in many cases

simultaneous visualization of artery was not possible in same window thus accidental artery puncture may occur. In oblique axis in plane (OAX-IP) approach, probe is aligned midway between SAX and LAX along with in-plane needle insertion from lateral to medial, thus allowing visualization of both IJV, artery and needle tip and path in same window.

The purpose of our study was to observe and compare three different real time 2-dimensional US-guided approaches (Short axis out of plane, long axis in plane and oblique axis in plane) and to determine which approach improves rate of successful cannulation and decreases complications along with shorter average time taken for the procedure. The primary outcomes of the study were venous access time, catheterization time and success rate. Secondary outcomes were number of patients requiring the second attempt and complications observed.

## METHODS

This prospective randomized study was conducted from December 2019 to November 2020 in a tertiary care centre after taking approval from institutional ethical committee (IEC). 120 adult patients of either sex and age between 18 years to 65 years undergoing emergency/elective surgery or during their stay in intensive care unit (ICU) who required IJV catheterization were included. Written informed consent was obtained from all the patients after explaining the procedure and study. Patients with age less than 18 years or more than 65 years, refusal for consent, any infection or surgical intervention at cannulation site, patients with cervical trauma, coagulopathy, IJV thrombus were excluded from the study. Sample size was calculated considering the success rate results from various studies. Sample size of 40 per group with power of 80% and significance level of 5% was calculated.

Patients were randomly divided into three groups by computer generated random numbers table: Group-I: IJV was identified with SAX view and real time US guided cannulation done with SAX-OP approach. Group-II: IJV was identified with SAX view and real time US guided cannulation done with LAX-IP approach. Group-III: IJV was identified with SAX view and real time US guided cannulation done with OAX- IP approach.

All US guided catheterizations were performed by well-trained anaesthesiologists having more than two years' experience in US guided procedures to minimize the effect of experienced person on data collection.

In all patients, before each procedure, an intravenous access, non-invasive blood pressure, electrocardiogram and pulse oximetry were established. In operating room, general anaesthesia was induced before the procedure. For awake patients in ICU, 2% lignocaine infiltration at puncture site was done. All patients were placed in 15-

20-degree Trendelenburg position with head turned to left side. Right sided IJV cannulation was done with triple lumen 7 Fr, 16 cm central venous catheter with soft J tip guidewire. All procedures were done under aseptic conditions by Seldinger technique with 18 G 70 mm Y-type introducer needle with 5 ml syringe attached to it. Real time ultrasound machine Micromax, linear high frequency probe 8-12 MHz was used with probe marker oriented to patient's right side with same operator handling the transducer and needle. In all patients, transducer was first placed parallel and superior to the clavicle over the groove between sternal and clavicular heads of the sternocleidomastoid muscle to visualize the IJ vein and surrounding structures (including carotid artery) simultaneously. All needle punctures were done under ultrasound guidance.

In group I transducer was placed transversally over the neck, parallel to the clavicle, and once the vein was visible, needle was introduced out of the plane of the transducer. In group II SAX view was obtained by placing transducer transversally over the neck, and once the vein was visible, transducer was then rotated longitudinally and placed perpendicular and superior to the clavicle over the groove between sternal and clavicular heads of the sternocleidomastoid muscle to visualize the IJV and carotid artery in long axis view. IJV was punctured using in plane technique and needle was advanced further with all-time visualization of the tip and shaft of the needle cranially to caudally and cannulation procedure was completed as usual keeping LAX view. Artery may or may not be visualized in same LAX view according to anatomy of the patient. Tilting or toggling of the probe was done to confirm location of carotid artery and IJV so that carotid artery puncture may be avoided. In group III OAX was obtained by first SAX view and then transducer was rotated midway between SAX and LAX views. Needle was inserted in plane from lateral to medial direction and cannulation procedure was completed keeping OAX view.

After vein puncture and blood aspiration, syringe was removed, j-wire was introduced through Y-shaped needle. After identification of J-wire inside jugular vein by ultrasound, catheter was inserted and fixed by same anesthetist. Post procedure chest radiograph was obtained for catheter tip position and any complication. A needle withdrawal was considered an attempt whether or not a new skin puncture was done. Maximum three attempts were allowed. A cannulation was considered unsuccessful if the cannulation was performed using different approach from that to which the patient has been randomized. Parameters like venous access time (the time taken from picking of the Y shaped introducer needle till aspiration of blood through syringe), catheterization time (time taken from attaching J-shaped guidewire to Y-shaped introducer needle till aspiration of blood through double lumen guidewire), number of patients requiring second attempt were noted. Complications like internal jugular venous posterior wall puncture, carotid artery

puncture (pulsatile flow of bright red blood through puncture needle), localized hematoma, pneumothorax, hemothorax, catheter tip malposition were noted and confirmed by chest X-ray or ultrasonography where appropriate.

### Statistical analysis

Statistical analysis was done by SPSS software version 20.0 (SPSS Inc., Chicago, IL, USA). All continuous variables were presented as Mean±SD. For continuous variables, one way ANOVA test was used to identify differences between the three groups and Chi Square test was applied for categorical variables. A p value less than 0.05 was considered significant.

## RESULTS

In our study, total 120 patients were randomized in three groups. The patients' demographic data was comparable between the three groups as shown in the Table 1.

**Table 1: Demographic profile.**

Variables	Group I	Group II	Group III	P value
<b>Age (years) (Mean±SD)</b>	32.73±11.76	35.47±15.72	35.32±16.25	>0.05
<b>Body mass index</b>	23.75±4.23	24.22±4.85	24.31±4.67	>0.05
<b>Sterno-mandibular distance (cm)</b>	15.6±2.86	15.3±2.29	14.9±2.93	>0.05
<b>Neck circumference (cm)</b>	38.3±4.77	39.6±4.38	39.2±4.51	>0.05

Analysed by ANOVA test

Venous access time was 24.53±5.56 seconds for group I, 21.84±3.67 seconds for group II and 26.53±4.89 seconds for group III and the difference was just significant between the groups. Catheterization time was 378±181 seconds in group I, 241±123 seconds in group II and 279±134 seconds in group III and this was statistically insignificant. Cannulation success rate in group I with short axis approach was 77%, in group II with long axis approach was 98% while in group III was 92% and the difference was significant between the groups. Number of patients out of 40 in each group who required second attempt were 4 in group I, 1 in group II and 3 in group III which was insignificant statistically as shown in the Table 2.

Posterior IJV wall puncture was observed in four patients in group I. Localized hematoma was observed in three patients in group I and one-one patient in group II and group III as shown in the Table 3. No other complication was observed in any group. This was statistically insignificant.

**Table 2: Parameters.**

Variables	Group I	Group II	Group III	P value
<b>Venous access time (second), (Mean±SD)<sup>#</sup></b>	24.53±5.56	21.84±3.67	26.53±4.89	0.05
<b>Catheterization time (second), (Mean±SD)<sup>#</sup></b>	378±181	241±123	279±134	0.076
<b>Cannulation success, (%)<sup>§</sup></b>	77	98	92	<0.0001
<b>Number of patients with second attempt, n (%)<sup>§</sup></b>	4 (10)	1 (2.5)	3 (7.5)	0.391

<sup>#</sup>ANOVA test applied, <sup>§</sup>Chi square test applied

**Table 3: Complications.**

Variables	Group I	Group II	Group III	P value
<b>Posterior IJV wall puncture, n (%)</b>	4 (10)	0	0	<0.05
<b>Carotid puncture</b>	0	0	0	>0.05
<b>Localized hematoma, n (%)</b>	3 (7.5)	1 (2.5)	1 (2.5)	>0.05
<b>Pneumothorax</b>	0	0	0	>0.05
<b>Arrhythmia</b>	0	0	0	>0.05

ANOVA test applied

## DISCUSSION

The use of ultrasound for IJV access results in a higher successful cannulations in first attempt with shorter average time for cannulation and reduction in mechanical complications when compared to landmark approach.<sup>5</sup> National Institute of clinical excellence guidelines recommend that ultrasound should be considered in most clinical circumstances where central venous cannulation is indicated.<sup>6</sup> USG-guided IJV cannulation is performed using different approaches like SAX, LAX, OAX and each technique has its own advantages and disadvantages.<sup>4</sup> In the SAX approach, the vessel is viewed in cross-section and allows the simultaneous visualization of both the artery and the vein but makes the control of needle tip difficult. In LAX view, the probe is centred on the IJ vein and rotated through 90° in a clockwise direction resulting in an LAX image of the vein. The probe needle and the blood vessel are in the plane of the ultrasound beam and therefore can optimize the needle visualization, but it displays only the vein in the ultrasound image and does not allow the visualization of relevant surrounding anatomic structures. In the majority of patients, the IJV lies lateral to the carotid artery and as one moves more cranially, it comes closer and anterior to carotid artery.<sup>1</sup> OAX technique

combines the benefits of the above two techniques. OAX view is obtained by initially obtaining SAX view and then the probe is rotated 30° counterclockwise. With this technique, IJV and carotid artery can be seen beside each other and the needle shaft and tip are observable in its entire direction hence the risk of carotid artery puncture is decreased in this approach.<sup>4</sup> The purpose of our study was to find safe and effective approach.

IJV cannulation was possible in all patients in our study. However successful cannulation (needle pass and blood aspirated through IJV) with designated approach was achieved in 77% of patients in SAX group, 98% in LAX group and 92% in OAX group which was found to be significant statistically. Most of the studies have not specified the definition of successful cannulation and it varied from <3 attempts to <7 attempts and some investigators have defined it as access time less than 4 minutes.<sup>7</sup> Batllori et al found first needle pass successful cannulation in 69.9% patients in SAX group, 52% patients in LAX group and 73.6% patients in OAX group.<sup>4</sup> They considered unsuccessful cannulation if the cannulation time exceeded 180 seconds. Chittoodan et al in 2011 found first attempt success rate in SAX as 98% and in LAX as 78%.<sup>9</sup> The difference in findings may be due to differences in definitions of successful cannulation. Our study findings are similar to Shrestha et al who found higher first attempt success rate for LAX (67.9%) than for SAX (51.2%) and they defined first pass success as single skin puncture and no needle redirections.<sup>8</sup> Chaudhari et al compared SAX and LAX approach in 50 patients and found that first pass success rate was more in LAX (92%) as compared to SAX (76%).<sup>10</sup> Caffery in 2018 found highest successful cannulation on first attempt in longitudinal approach (82.9%), followed by transverse approach (78.9%) and oblique approach (76.9%).<sup>11</sup> which are similar to our findings. We found highest percentage of successful cannulation in LAX group, lesser in OAX group and least in short axis approach. We found more difficulty in advancing the guidewire in SAX as compared to OAX and LAX which might have attributed to less successful cannulation in SAX group.

In our study, mean venous access time was lowest for long axis group (21.84±3.67 seconds) as compared to short axis group (24.53±5.56 seconds), and oblique axis group (26.53±4.89 seconds) which was statistically just significant. Caffery found mean skin to vein time as 17.6 sec in SAX, 18.4 sec in LAX and 19.2 sec in OAX approach. Vogel also found lesser median time (9.5 sec) for IJV cannulation in long axis than short axis (14.5 sec).<sup>12</sup> Tammam found mean venous access time as 52.3 sec for SAX and 52.7 sec for LAX with no statistical difference between the groups which is similar to our findings. Batllori found mean cannulation time as 35 sec in SAX, 46.1 sec in LAX and 41.2 sec in OAX group. The difference in findings may be because there might be differences in the experience of anaesthesiologists performing the procedure.

Mean catheterization time was least for LAX group 241±123 seconds than 279±134 seconds in OAX group and maximum time taken was 378±181 seconds in SAX group, but this was statistically insignificant. Balaban found mean catheterization time as 40 sec in SAX and 52 sec in OAX with no statistical significance. He defined catheterization time as the time starting from the first skin puncture until the placement of guidewire into the vein without resistance and withdrawal of the needle.<sup>13</sup> We had higher value because we noted time until blood aspirated from triple lumen catheter.

Second attempt was required in 10% patients in SAX group and 2.5% patients in both LAX and OAX group and the difference was statistically insignificant. Vogel found LAX approach was associated with significant decrease in the number of redirections in IJV cannulation.

We in our study found higher incidence of complications in SAX group as compared to other groups. Four patients (10%) in SAX group had IJV posterior wall puncture and none in LAX and OAX and the difference was statistically significant. Localized hematoma was found in three patients (7.5%) in SAX group, one patient (2.5%) in LAX group and one patient (2.5%) in OAX group with no statistically significant difference. Batllori found incidence of IJV posterior wall puncture as 11% with SAX and 1.4% with OAX which is similar to our study. Chittoodan found carotid artery puncture in LAX group in 4% patients. Shrestha found one incidence of carotid artery puncture in both SAX and LAX group. Tammam found one incidence of localized hematoma and one incidence of carotid artery puncture and the difference was insignificant. Vogel also found lesser posterior wall puncture in LAX view (21%) than SAX view (25%) and these findings were similar to our findings.

The present study supports the superiority of long axis view in terms of higher cannulation success for the approach chosen, lesser average venous access time and catheterization time, lesser number of patients requiring second attempt and lesser complications. It has the primary advantage of visualizing the advancing needle tip and guidewire. Carotid artery can be identified by toggling the ultrasound probe and in this way both IJV and artery can be distinguished during cannulation and carotid artery puncture could be minimized. The visualized needle pathway is larger in LAX view as compared to OAX and this might help in increasing the success rate. Vogel and colleagues also reported that long axis view was more efficient than short axis view for IJV access.

This study has several limitations. Oblique axis views in medial and lateral orientation of probe were not noted and compared. Respiratory cycle phases of inspiration and expiration were not noted during IJV puncture.

## CONCLUSION

Despite the oblique approach having advantage of optimizing the pathway of needle tip and vessels during IJV cannulation, we found longitudinal approach LAX-IP showed better performance than other approaches in terms of higher cannulation success for the approach chosen, lesser average venous access time and catheterization time and lesser complications. On toggling USG probe, both IJV and carotid artery can be differentiated during needle insertion and carotid puncture could be avoided. Hence LAX approach is safer and effective approach than other approaches for USG guided IJV cannulation.

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