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A prospective randomized study to compare short axis and long axis techniques of ultrasound guided internal jugular vein catheterizations

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Abstract
Context: Central venous catheterization (CVC) is integral part of management in modern era. Studies have compared different approaches of Ultrasound guided CVC, but still inconclusive.
Aims: Comparing ultrasound guided CVC techniques, short vs long axis, for novice ultrasound operator with respect to successful cannulation (SC), venous access time (VAT), attempts, cannulation time (CT) and complications.
Design: Prospective, randomized, comparative study.
Methods and Material: Study includes 60 patients >18 years, requiring CVC, undergoing surgery under general anaesthesia. Ipsilateral Internal Jugular Vein (IJV) cannulation in past 72 hours, ipsilateral AV fistula, coagulopathy, IJV thrombosis, subcutaneous hematoma/emphysema, infection, erosion and previous surgical intervention at or near puncture site were excluded. Two groups, Long (L) and Short (S) Axis, formed using random number table. Single anaesthetist novice ultrasound operator performed cannulation.
Statistical analysis used: SPSS17.0 version used. Student's T test and Mann Whitney U test used for continuous variables. Nominal categorical data compared using Chi-square and Fisher's exact test. $p<0.05$ considered statistically significant.
Results: Demography and clinical characteristics were comparable. SC in S group (86.7%) was comparable to 'L' group (80%). VAT in 'S' and 'L' groups was 49.73+/-19.87 and 52.5+/-19.7 respectively. Two patients in 'S' while 5 in 'L' group required >3 cannulation attempts. CT in both groups was comparable (P=0.928). Complication rate was higher in 'L' (13.3%) vs 'S' group (3.3%).
Conclusions: Short and long axis approaches of ultrasound guided IJV catheterization are comparable in terms of SC, attempts, VAT, CT and complications. Further multi-centric trials with larger cohort are needed.

Keywords: Central venous catheterization, short axis, long axis, ultrasound

Introduction
Central venous catheterization (CVC) is an integral part of management in the modern era. It can be said without exaggeration that the rapid administration of fluid, wide range of hemodynamic monitoring, total parenteral nutrition, hemodialysis etc. would not be possible without this procedure.
Many anatomical landmark guided techniques for internal jugular vein (IJV) puncture have been described [1]. But high first pass failure rate and substantial risk of overall complications discouraged these techniques [2]. Ultrasonographic guidance in central venous access has converted a blind procedure into a "procedure under vision." Ultrasound (US) allows identification of the target and collateral structures and real time guidance to precisely place needles [3].
Two commonly described US guided techniques in literature are Long axis (in plane) and Short axis (Out of plane). Both these techniques have their own advantages and disadvantages. But a lack of understanding of how to assess the position of invasive devices and in particular the location of the needle tip is a major obstacle. We have focused on ways to learn the skills needed for safe ultrasound-guided central venepuncture. The most difficult point is to get the trainee to understand the pitfalls associated with two-dimensional imaging, since a two-dimensional view is not easily translated to the three-dimensional real world of the clinical setting.

Many studies have come up comparing different approaches of US guided CVC using varied variables [4-11]. Some studies have also focused on understanding the learning curve for different approaches of US guided CVC on inanimate model [5, 6]. But still the debate is inconclusive. Therefore, we aimed at comparing two well-known approaches of US guided CVC, short axis (SAX) and long axis (LAX), for a novice US operator with respect to successful cannulation, venous access time, number of attempts of cannulation, time taken for successful cannulation and complications.

Methods

After obtaining approval from the institutional ethical committee we conducted a prospective, randomized control, comparative study.

Patients more than 18 years of age undergoing surgery under general anaesthesia between December 2016 and November 2017, in whom CVC was indicated, were included in the study.

Patients having history of ipsilateral IJV cannulation in past 72 hours, AV fistula on same side, coagulopathy (INR values > 1.5 and platelet count <50,000) or with presence of IJV thrombosis were excluded. Also patients with cutaneous erosions, subcutaneous hematoma, subcutaneous emphysema, signs of infection and previous surgical intervention at or close to puncture site were excluded. Thus, 60 patients formed the study cohort.

Written and informed consent was taken from the patients for the procedure. The patients were randomly enrolled into two groups. Randomization was done using random number table for obtaining the numbers which was placed in the sealed envelopes for randomization.

Group L - Long axis technique was used in this group.

Group S - Short axis technique was used in this group.

We used 2D Ultrasound machine with 12 MHz linear probe and triple lumen Arrow central venous catheter. Each cannulation was performed by single anaesthetist who is new for both the above mentioned techniques of ultrasound. An observer was present during the procedure for making observations. Subjects undergoing surgery under general anesthesia were placed in 30 degree head low position with head turned slightly on the opposite side. Since right side IJV has a more straight alignment, it was always attempted first except in cases of previous scars or thrombosis, in such cases left side was attempted first. Pre-procedural Ultrasound guided screening of IJV in the sedillot's triangle was done to rule out IJV thrombosis or presence of any hematoma. Following observations were recorded:

Successful Cannulation - Cannulation was considered successful once a flexible guide-wire has been satisfactorily inserted into the internal jugular vein [4, 9].

The procedure where we took >3 number of attempts or >180 seconds for cannulation, was considered as failed or unsuccessful cannulation.

Venous access time - Time between insertion of needle into the skin to aspiration of blood in syringe [10].

Cannulation attempt - puncture of skin to aspiration of blood without change of direction will be counted as an attempt. Withdrawal and change of direction will be counted as a new attempt [4, 9].

Ultrasound probe was placed longitudinally (i.e. paraller to IJV axis in group L) and transversely (i.e. perpendicular to IJV axis in group S) at the junction of sternal and clavicular heads of sternocleidomastoid muscle and at the level of cricoid cartilage.

After the introduction of the needle (superior end of transducer probe in group L and mid-point of the longitudinal axis of the probe in group S), the needle tip and shaft was visualized. The time taken for free flow of venous blood entering the syringe was noted. Further movement of needle was stopped and guide-wire was introduced. Seldinger technique was used for catheter placement [12]. Catheter was fixed using suture material and sterile dressings.

Correct catheter placement was confirmed by ultrasound guided visualization of the guidewire. In the recovery room, post procedural chest x-ray was advised to identify complications like pneumothorax and mal-positioning of catheter. All complications were treated accordingly.

Statistical testing was conducted with the statistical package for the social science system version SPSS 17.0. The comparison of normally distributed continuous variables between the groups was performed using Student's t test. Nominal categorical data between the groups was compared using Chi-squared test and Fisher's exact test. Non-normal distribution continuous variables were compared using Mann Whitney U test. For all statistical tests, a P value less than 0.05 was considered statistically significant.

Results

Patients characteristics and clinical data are summarized in table 1. Both groups are comparable in terms of demography and clinical characteristics.

Table 1: Demography and Clinical Characteristics

	Group L	Group S	P value
Age	44.83 (SD 13.4)	41.33 (SD 11.62)	0.208
BMI	26.017 (SD 3.19)	25.876 (SD 4.48)	0.889
Heart Rate	83.97 (SD 8.32)	86.1 (SD 5.85)	0.255
SBP	147.57 (SD 12.42)	152.33 (SD 11.3)	0.125
DBP	87.13 (SD 8.74)	91.77 (SD 11.66)	0.087
SPO2	98.97 (SD 0.77)	99.03(SD 0.96)	0.768
Platelet count	2.64 (SD 0.71)	2.17 (SD 0.79)	0.018
INR	0.95 (SD 0.11)	1.02 (SD 0.15)	0.044

In 60% of group S patients, IJV cannulation was done in single attempt as compared to only 36.7% group L patients. Two attempts were made for IJV cannulation in 23.3% and 30% patients of group S and group L respectively. 10% group S members required three attempts for IJV catheterization whereas in group L 16.7% IJV catheterization needed three attempts. In group S, IJV cannulation was done in >3 attempts in only 2 cases out of 30 as compared to 5 cases out of 30 in group L (Chart 1).

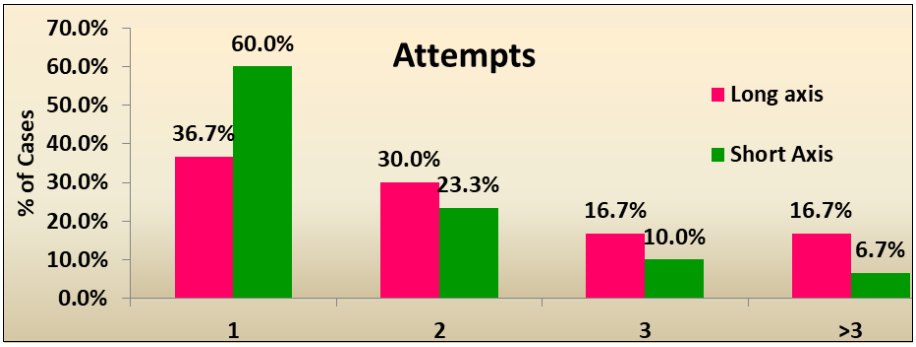

Chart 1: Number of Attempts

The mean venous access time for group S was 49.73±19.87 sec while it was longer for the group L 52.5±19.7 sec. with no statistically significant difference (Table 2).

The time taken for cannulation in both groups is almost same. It was 114.63±40.08 in group L and 113.63±45.03 in group S (P value = 0.928) (Table 2).

Table 2: Venous access time and Cannulation time

	Group L	Group S	P Value
	Mean±SD	Mean±SD	
VAT	52.50±19.72	49.73±19.87	0.590
CT	114.63±40.08	113.63±45.03	0.928

The rate of successful cannulation in group S (86.7%) is more than group L (80%). But the P value of 0.731 made this difference statistically insignificant (Chart 2).

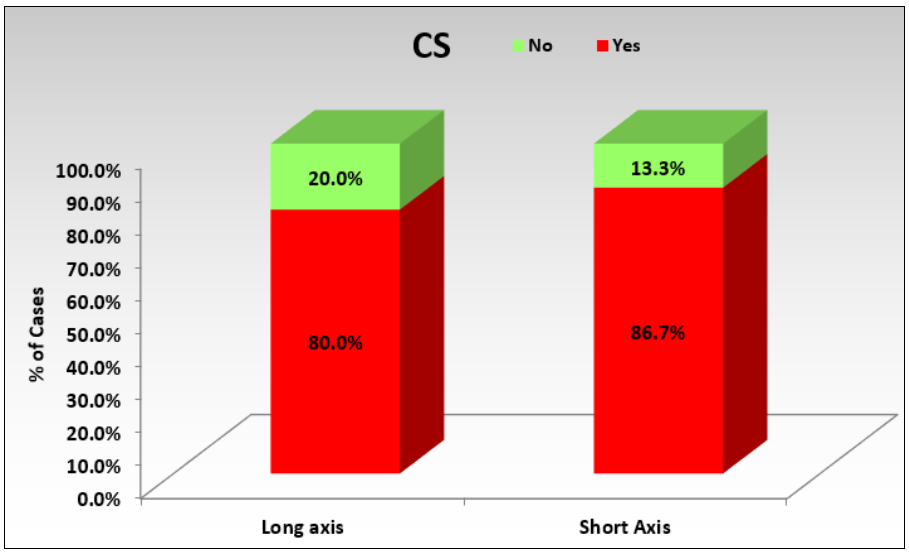

Chart 2: Successful Cannulation Rate

The failure rate in group L is 20% whereas it is 13.3% in group S (P value= 0.731) making it statistically insignificant (Chart 3).

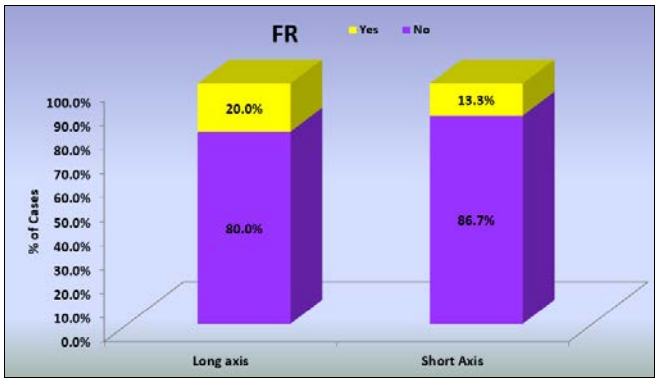

Chart 3: Failure Rate

The incidence of complication is 3.3% in group S whereas it is 13.3% in L group. Here the p value is 0.353, showing statistically insignificant difference between the groups. One carotid artery puncture, two cases of hematoma formation and one mal-position seen in group L, whereas only single case of hematoma was found in group S (Table 3).

Table 3: Complications

Complications	L group	S group	P value
Carotid artery puncture	1	0	1.000
Hematoma	2	1	1.000
Malposition	1	0	1.000
Pneumothorax	0	0	-

Discussion

We had 50 cases of successful cannulations out of 60 (24/30 in L and 26/30 in S group). In L group, 5 cannulations were

considered as failed cannulation because more than 3 numbers of attempts were required to perform the procedure. The time required to cannulate the IJV was found to be more than 180 seconds in one case of group L and therefore, it was also labeled as unsuccessful cannulation as per our definition. In S group, we required more than 3 attempts for IJV cannulation in 2 members whereas the remaining 2 had cannulation time of more than 180 seconds. Therefore, the above 4 cases of S group were labeled as unsuccessful cannulation. We did not find statistically significant difference in successful cannulation rates between the two groups (P value 0.731). Although the first pass successful cannulation in S group is 60% and 36.7% in L group (P value = 0.071).

But there are studies by M. Batllori *et al*. (220 cases) and Suresh Chittoodan (99 cases) concluding that the first needle pass successful cannulation was higher with the S group with success rate ranging between 69.9% to 98% as compared to success rate 52% to 78% with L group [4, 7]. This could be because the study was being performed by experienced and proficient anesthetists while in our study the operator was inexperienced and new to the procedure.

Madhavi Sanjay Chaudhari *et al*. Did a prospective randomized observational study in which USG guided internal jugular vein (IJV) cannulation was done by trainees (post graduate students). Higher first attempt successful cannulation and overall less complication were seen in long axis approach (92% versus 76%) though this was not statistically significant [11]. Although cannulations were done by novice operator but in their study first needle pass success rate was more with LAX which they attributed to improved needle visualization after correct identification of the single vessel in the scanning field.

In S group of our study, 60% cases needed single attempt for IJV cannulation whereas, single attempt venous cannulation was seen in only 36.6% cases in L group. But this visible difference is statistically insignificant (P value 0.071). Two attempts were made for IJV cannulation in 23.3% and 30% patients of group S and group L respectively.

10% S group members required three attempts for IJV catheterization whereas in group L 16.7% IJV catheterization needed three attempts. So, total number of attempts in group S was found less than group L but the difference is statistically insignificant.

We have studies in literature showing similar results. In 2003, M. Blaivas *et al* conducted a prospective, randomized, observational study of emergency medicine residents, comparing SAX and LAX approaches of USG guided venous access on inanimate model. The mean number of skin penetrations with the needle (SAX 4.18 versus LAX 5.76) and number of needle withdrawals and redirections (SAX 13.71 versus LAX 18.17) showed no significant difference between LAX and SAX approach [5]. However, according to Suresh Chittoodan, in the hands of experienced operators, this difference was found to be statistically significant. In the short axis, on US, the vessel appears to be a dark circle, easy to localize and thus less alignment of US probe with vein is needed. However, In the LAX, the entire length of the needle can potentially be tracked on the US screen as it enters the blood vessel but this requires more hand-eye coordination and expertise than the SAX approach [7].

On the contrary, comparable results were found between the groups in terms of skin puncture but significant decrease in the number of redirection was found to be associated with LAX approach (Relative risk 0.4) as compared to SAX approach in the study done by Jody A. Vogel *et al*. The reason stated behind this finding was better visualization of needle with long axis [8].

In our study, we observed faster venous access was achieved with SAX [49.73 (SD 19.87)] as compared to LAX [52.50 (SD 19.72)] but the difference was statistically insignificant (p value 0.590). The time taken for cannulation in both groups is almost same. It was 114.63±40.08 in group L and 113.63±45.03 in group S (P value = 0.928).

In other studies where novice operator performed, found similar observation as our study in venous access time. Since they did their study on inanimate models they did not observed cannulation time [5, 13].

On the contrary, faster venous access was seen with LAX (median time 10 sec) as compared to SAX (15 sec) in a study done by Jody A. Vogel *et al*., comparing these two approaches for the cannulation of IJV and subclavian vein with the help of 28 resident physician on human torso mannequin, but the difference is statistically insignificant and especially for novice operator, they recommended SAX approach of US guided IJV cannulation for localization of vein [8].

Although the LAX approach to vessel cannulation affords unique advantage of better and continuous visualization of needle, but maintaining the needle in the plane of the ultrasound beam may be challenging, especially for novice ultrasound operators. So, the loss of imaging during the procedure and re-localization of venous field could be considered as the reason behind prolong procedural time with LAX approach.

According to the study in which interventions were done by experienced operator, the VAT in both groups was quite comparable. According to them, visualization of the IJV on the short axis was particularly useful for catheterization of the small vessels, whereas the primary advantage of the longitudinal view is to visualize the advancing needle tip [10].

Similar to the results of our study, CT was found to be comparable with SAX and LAX approach in Gentle Sunder Shrestha *et al* and Suresh Chittoodan *et al* study. In both the above mentioned studies IJV cannulation of patients was performed by skilled operator. According to them, SAX approach losses the continuous needle visualization and making the procedure based on judgement of the operator whereas LAX approach overcome the problem of needle visualization but it has its own technical challenge of skillful and effective work of hands and eyes [7, 9].

However, in the study done by M. Batllori *et al* comparing SAX, LAX and oblique axis for US guided IJV access on 220 critical cases in which operator were trained anesthetist, they found a statistically significant difference in cannulation time between the two approaches [LAX (46.1) versus SAX (35.0) and the p value is 0.039]. According to them, SAX has traditionally been the approach preferred by clinicians for performing and teaching ultrasound-guided IJV cannulation. So, the trained anesthetists were more comfortable with SAX approach. They also considered that this difference, although statistically significant, may have no clinical significance [4].

Here, we can clearly notice that the venous cannulation time in our study was nearly double the time needed for

cannulation in other studies. Experience of the performing candidate would have played role in this task.

In our study we encountered complications like carotid artery puncture, hematoma and malposition. None of our patients had pneumothorax and nerve injuries.

Carotid artery puncture was seen in only one case using LAX approach while no such complication occurred with SAX approach. Suresh Chittoodan *et al* in his study had found a definite trend towards more carotid artery puncture with long axis view comparing short axis view (48:2 versus 49:0 $p<0.48$). But the difference was not statistically significant, similar to our study. They explained, only one vessel was visualized in long axis view on the ultrasonography screen which could be confused for the vein. Both the vessels are seen on the single screen in SAX, making the identification of vein easier with less arterial puncture [7]. It possibly explains more incidence of hematoma and carotid artery puncture (CAP) incidence with LAX in our study too.

In Madhavi Sanjay Choudhary *et al* study 4 out of 25 patients in the short axis group had inadvertent arterial puncture. There was no arterial puncture in the long axis approach. These results were different from our study. They considered LAX a better approach if arterial punctures are to be avoided, provided correct identification of vein is done prior to needle insertion [11]. M B Stone *et al* also observed similar facts. Thus they concluded, in short axis the person may lose the track of the needle and may cause inadvertent arterial puncture if he is not well versed with ultrasound machine [13].

We have seen the incidence of hematoma in both the groups. In S group only one case had this complication whereas there were two cases of hematoma seen in L group. In L group, the one case where we found hematoma, also had carotid artery puncture. Thus, hematoma can be seen with either venous or arterial injury. Possible explainations were given by studies, discussed below, regarding venous injuries with US guided cannulation.

In M Blaivas *et al*. and Jody A Vogel *et al*. studies, cannulation was done by resident physicians on inanimate model. Both found that in the SAX approach to the IJV, inadvertent posterior wall puncture occurred in the majority of catheterization attempts and the ultrasound operator was unaware of this outcome. The authors of the study suggested that ultrasound operators be particularly cautious about the location of the needle tip when visualizing the vessel in the SAX or cross-sectional approach [8, 14].

Since M Blaivas *et al* and Jody A Vogel *et al* studies were not conducted on patients, similar reflection of results on live patients may not be justified.

In our study, we had one incidence of malposition which was seen in L group.

Conclusion

To conclude, short and long axis approaches of ultrasound guided internal jugular vein catheterization are found to be comparable in terms of success rate, number of attempts, venous access time, cannulation time and complications. All these observation draw a conclusion of similar learning curve with short axis and long axis techniques of ultrasound guided IJV catheterization for a novice operator. However, a multicentric trial, large sample size and numerical parameter for explaining learning curve could have strengthened the study.

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