A comparative study between ultrasound guided catheterization of the internal jugular vein and classical landmark technique

Dr. Tintu Jacob¹, Dr. Rajeev Dwivedi ²*, Dr. Sudhakar Dwivedi ³
Postgraduate Student, Associate Professor, Professor and Head
Department of Anaesthesiology, Shyam Shah Medical College, Rewa, Madhya Pradesh

Corresponding Author:
Dr. Rajeev Dwivedi
Associate Professor, Department of Anaesthesiology, Shyam Shah Medical College, Rewa, Madhya Pradesh

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ABSTRACT

Background and aims: Central venous cannulation is important in the management of critically ill patients. Primary objective is to compare the USG guided technique with landmark guided technique for internal jugular venous cannulation in terms of success rate in the first attempt among the preoperative and intensive care patients admitted in a tertiary care hospital. Secondary objectives are to compare the number of attempts, time required for the procedure, change of skin puncture site, change over to subclavian vein cannulation, and the complications in two groups.

Methodology: Randomized controlled trial was conducted in sixty patients, thirty in each group, who were above 18 yrs. who require CVC scheduled for elective or emergency surgery or during their stay in the intensive care unit.

Results: The catheter was inserted in first attempt in 73.3 % patients in ultrasound group and 33.3 % in landmark group (p value .004) and mean number of attempts in landmark group (1.93) was higher as compared to USG group (1.30) with p value .001. Time to perform cannulation was much higher in landmark group (mean time 133.97 secs) as compared to USG group (mean time 89.9 secs) (p value .004). It was observed that artery was punctured in 33.3% cases in landmark group and 10 % in USG group (p value .023).

Conclusion: Ultrasound can be used as the first line in IJV cannulation to decrease complications and to improve the outcome of the procedure.

Keywords: Central venous cannulation, Internal jugular vein, ultrasound, landmark

INTRODUCTION

The IJV is the venous access of choice in the majority.¹ A method for cannulation of IJV by using external landmarks was first published in 1966.² Despite frequent training and practice, insertion of vascular catheter is associated with complications that vary between 5% and 19% (arterial puncture, pneumothorax, hemothorax, air embolism, cardiac arrhythmias.).³,⁴ Internal jugular catheterization is difficult in morbidly obese patients, in whom the landmarks of the neck are obscured and also in pediatric patients.⁵

Doppler ultrasound was first used to do central venous catheter insertion in 1984. Ultrasound has been applied to describe the anatomy of the IJV and to evaluate various techniques for percutaneous cannulation. The agency for healthcare Research and Quality recommends USG for the insertion of central venous catheters.⁶ Machi J et al. was of the opinion...
that USG has to be evaluated as an adjunct to central venous access under routine circumstances.7 Bart G Deny et al. said that USG has to be used to assess the normal IJV anatomy to refine the technique of percutaneous cannulation of IJV.8 Hatfield et al. showed that time taken for the procedure was less in USG and it also increases the success rate and reduces the complication.9

With the evolution of new technology, landmark method is replaced by USG guided technique. One of the primary reasons for not routinely using USG is lack of equipment, lack of theoretical and practical training. USG guided central venous puncture also yields complications but in lesser number as compared to classical landmark technique.10 But in our settings landmark method remains important for emergencies when USG equipment or expertise might not be immediately available. And the present study is carried to compare the effectiveness of ultrasound guided IJV cannulation with the classical landmark technique in terms of success rate in the first attempt, time taken for the procedure and in terms of complications.

METHODS

This randomized controlled superiority trial was conducted after obtaining institutional ethics committee approval. The study was conducted between from April 2019 to March 2020. The study population consisted of patients with age more than 18 yrs who require CVC, scheduled for emergency surgeries or during their stay in the intensive care unit (ICU). Thirty participants were allocated in each group namely the ultrasound-guided group (USG) and the landmark guided technique group after informed written consent. Randomization was done using the closed envelope method. In this, the principal investigator was given randomly generated treatment allocations within sealed opaque envelopes. Once a patient has given consent to enter a trial an envelope is opened and the patient is then offered the allocated group. Patients with previous neck surgery, head and neck mass or cancer, superior vena cava syndrome, coagulopathy, infection at the cannulation site were excluded from the study.

Standard monitoring (electrocardiogram, blood pressure, and pulse-oximeter) are applied to patients. The intravenous access obtained with appropriate size venous cannula. Intravenous fluid Ringers lactate was started. All patients were positioned in the Trendelenburg (20-30°) position with the head turned slightly toward the left side. The catheter is prepared and checked for patency. Anatomical landmarks (sternocleidomastoid muscles, sternal notch, cricoid cartilage, and clavicle) were assessed and marked. The right side of the neck region was prepared with an antiseptic solution. 2-3ml of Lignocaine 2% was used for local anesthesia. All the IJV cannulations in both the groups were done by the same investigator. The investigator had assisted an experienced anaesthetist and radiologist for 30 CVC before performing the procedure.

The technique for landmark method

An 22G finder needle attached with a 5 ml syringe was inserted at the apex of the triangle formed by the two heads of the sternocleidomastoid muscle, (at the level of cricoid) directed toward the ipsilateral nipple at an angle 35-45° angle with the skin. The carotid artery pulsation is felt by the non-dominant hand and the needle is inserted laterally to avoid carotid puncture. The needle is advanced with gentle aspiration and non-pulsatile venous blood entering into the syringe will confirm the entry into the internal jugular vein. Next the guide wire and catheter is placed by seldinger method. The ECG is monitored continuously to detect arrhythmias if the tip of the guide wire is inserted too far and is in contact with the right atrium. Patency of lumen was checked once again with heparinized saline.

The technique for USG guided puncture

The real-time 2D ultrasound-guided internal jugular cannulation requires 10 MHz transducer probe. The probe is protected with a sterile sheath and a jelly is used to improve the contact of the transducer to the skin. The ultrasound probe is placed perpendicular to the great vessels of the neck and a cross-sectional view of the vein is obtained. In this view, both the artery and vein are simultaneously seen and the differentiating features are verified before passing the needle. The vein is positioned in the center of the ultrasound screen. The vessel is punctured under direct vision with an 18G needle. The needle is passed out of the plane to the probe advancing at an angle (45°) until the tip of the needle is visualized as a white dot. In this view, the entire needle is not seen. Only the tip of the needle can be visualized. The puncture of the internal jugular vein is confirmed by
aspiration of non-pulsatile venous blood. The guide wire is inserted. The guide wire is seen as dot when transducer is held perpendicular and as a straight line when transducer is held parallel. The catheter placement was done by the Seldinger technique.

![Figure 1: The guide wire is seen as dot when transducer is held perpendicular and as a straight line when transducer is held parallel](image)

**Parameters observed**

1. Number of attempts: Defined as the number of times the needle was withdrawn and redirected till successful cannulation.
2. The time required for the procedure: Defined as the time taken from the first needle entry to the successful aspiration of venous blood from the lumen of the catheter.
3. Change over to subclavian vein cannulation: After 3 attempts or due to any complications in the right IJV cannulation, the site was moved to the right subclavian vein.
4. Accidental artery puncture: It denotes whether the artery got punctured during puncture. (Noted by forceful pulsatile expulsion of bright red blood from the needle)
5. Accidental pneumothorax: Number of times pneumothorax occurred. It was confirmed by taking chest X-ray after the procedures.
6. Any other complications-like haemothorax, arrhythmias, technical complications

**RESULTS**

The data collected was analyzed, continues variables were presented as means with standard deviation (SD) and categorical variables were presented as frequency and percentages. Student’s t-test was used for testing the significance of mean in both the group. Qualitative data was analyzed using Chi-square test. All the statistical results were considered significant at the p value <0.05.

<table>
<thead>
<tr>
<th>Demographic profile</th>
<th>USG (30)</th>
<th>LANDMARK (30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age(years)</td>
<td>42±19</td>
<td>47±20</td>
</tr>
<tr>
<td>Sex (F/M)</td>
<td>12/18</td>
<td>14/16</td>
</tr>
<tr>
<td>BMI</td>
<td>22.57±4.10</td>
<td>22.10±3.66</td>
</tr>
</tbody>
</table>

**Table 1: Showing the demographic profile of the population**
PARAMETERS | USG | LANDMARK | P value
--- | --- | --- | ---
Success at first attempt | 22 (73.4 %) | 10 (33.3 %) | .004
Time required | 89.90 sec | 133.97 sec | .004

Mean no of attempts | 1.30 | 1.93 | .001
Change over to subclavian cannulation | 0 (0%) | 5 (8.3%) | .052
Accidental artery puncture | 2 (10 %) | 10 (33.3 %) | .023
Pneumothorax, hemothorax | 0 (0%) | 0 (0%) |
Arrhythmias | 0 (0%) | 0 (0%) |

Table 2: Parameters observed in the study

![Ultrasound Group](image)

1st attempt | 2nd attempt
--- | ---
8, 27% | 22, 73%
DISCUSSION
The first attempt success rate
In our study, single attempt catheterization was seen in 73.33% of patients in USG technique group as compared to 33.33% in LMG technique group which was statistically significant (p-value = 0.001).

Farrell et al.6 in their study on 69 patients found 83.3% success rate in first attempt in ultrasound technique group as compared to 35.9% in the landmark group (P<0.0001), which was comparable with our study. They conducted the study on patients for hemodialysis. Another study with the same result was the study by Bart G.Deny et al.8. They showed success in 78% in USG technique and 38% in landmark technique on the first attempt. They tried Valsalva maneuver to enlarge the size of the IJV. They hypothesized that absence of vein probably...
indicate occlusion or thrombosis and small vein may be scarred by multiple attempts. They evaluated 626 patients for this study. Shrestha et al.11 also had a similar result, 63% success in USG and 32% in the landmark. They concluded that short neck, anteriorly located vein and collapsed vein might be the causes for failure rate in IJV.

Even though the success rate at the first attempt using ultrasound is high compared to the landmark technique it mainly depends on the skills and experience of the performing person and number of operators. That explains different success rate at the first attempt in the different literature. This observation was strengthened by the study done by K. Rando et al.12 Here, the 257 patients were divided into two groups: Expert group (who performed >70 central lines before performing the procedure) and non-expert group (in training group). They found out that overall success was 88% (expert group) vs. 79% (non-expert group) in USG group and 91% (expert group) and 78% (non-expert group) in landmark group. In our study, principle investigator has performed 30 central venous cannulation before starting trial thus explains the lesser success rate.

Mey et al.13 reported the efficiency of USG technique when performed by two operators. That is, one performing the scan and other performing the procedure. The study concluded that the single most important factor under USG technique was the operator’s experience. Slama et al.14 also reported 76% success in landmark group and 100% success in USG group with experienced 2 operators. It was noted that in our study, the procedure was done in mono operator mode. i.e. operator had to perform puncture and USG scan simultaneously. The IJV was fully compressed by the needle before the vessel got penetrated. The needle must be advanced a little deeper and then retracted to be positioned in the center of the lumen. Failure to recognize this might be the reason for the more than one attempt in the ultrasound technique.

Number of attempts taken

Maximum three attempts were allowed in each group in this study. After the third attempt, the subclavian vein was chosen. We were not able to cannulate IJV in 5 patients in the landmark group. The failure rate was 8% in the landmark group in this study and zero in USG.

According to Stefanidis et al.15 more than 18% of the patients in the landmark group required more than 3 attempts, while in USG group all cannulations were successful within one – three attempts (p <0.01). Thus under USG guidance, the success rate is increased. This result is consistent with this study. Shrestha et al.11 They had 12% failure in landmark method and they salvaged it by USG. They could not cannulate 3% of patients in USG due to artery puncture and hematoma formation. Similar result was also reported by Henjarappa et al.16. They reported 100% success in the first attempt in USG and in landmark group 83% in 1st attempt, 6.7% in the second attempt and 10% in the third attempt. But it was not statistically significant. (p=.065). Maximum of 3 attempts were done in the landmark group and only single attempt in USG group.

Most of the studies have not specified “failure”. Some described >three attempts as failure similar to our study. Some others considered >seven attempts and even access time more than 4 min as a failure. We found out that with repeated attempts, there were more complications.

The time required for the procedure

The access time was shorter in USG technique with a mean of 89.90 seconds ± 21.59 seconds and in landmark group 133.97 ± 77.43 seconds. Turk et al.17 showed a mean time of 95 ± 136 sec in USG group and 236 ± 110 sec in the landmark group. Here similar to our study, time is defined from the first puncture to return of venous blood in the catheter. Here the operator is a senior medical student in the final year.

According to Henjarappa et al.16 the mean cannulation time was 152 ± 95.4 seconds in the USG group versus 323 ±146.5 seconds in the landmark group (p<0.001). This is longer compared to our study. Here time was calculated from initial skin puncture to skin suturing. Bart G Denys et al.8 showed that average access time was 9.8 sec by USG approach and 44.5 sec by landmark approach (p <0.001). This is too short compared to our study. Here they took into account only the venous access time.

Ray B R et al.18 had studied venous access time (insertion of the needle to return of blood in the syringe) and catheterization time separately (starting
from the introducer needle to the end of catheter insertion, excluding suturing and fixation time.). The venous access time was 14.5 sec in the landmark and 11 sec in USG. Catheterization time was 225 sec in the landmark group compared to 165 sec in USG group.

Such a big variation in time required could be ascribed to different definitions of ‘time’ in different studies and the skill of the individual placing the central venous catheter.

Change over to subclavian cannulation

Five patients (16.7%) in landmark group had to change over to subclavian cannulation (because of inability to cannulate right IJV within three attempts or due to complications). All IJV cannulations were successful in USG group (p-value =0.52, not significant.).

This finding was consistent with the study done by Filho et al.35 they showed that USG had a lower incidence of changing to subclavian cannulation (USG =0 %, landmark group =23 %). But in other studies, they salvaged the failure cases with USG guidance technique. In the study done by Farell et al.6 7 patients out of 69 patients in whom landmark had failed, they placed it under the USG guidance. Shrestha et al.11 also replaced unsuccessful landmark guided cannulations with USG guidance. Few other studies shifted to the opposite side for failed cannulations. (Henjarrapa et al.16 Dimitrios et al.20)

Accidental artery puncture

The artery got punctured in ten cases (33.3%) in landmark compared with two cases (10%) in ultrasound-guided technique. But other studies in the literature showed artery puncture ranging from 4% to 19.4% in the landmark group. {Dimitrois et al.20, Farell et al.6, Filho et al.19, Turker G et al.17, Agarwal A et al.21, Slama M et al.14}. Arterial puncture is the most frequent complication of IJV catheterization because of its close anatomical proximity to the IJV. Sometimes the puncture needle goes across the blood vessel. This along with overlap results in a more arterial puncture in the landmark group. In addition to these, difficult neck situation posed additional difficulty in the landmark group. Also this difference may be associated with the skill of the individual placing the central venous catheter in different studies.

Accidental pneumothorax

There was no pneumothorax during the study procedure.

Turker G et al.17 and Bart G Denys et al.8 reported zero case of pneumothorax in either group. This is comparable to our study. But Agarwal A et al.21 have reported that 2.5% cases of pneumothorax in landmark group versus no cases of pneumothorax in USG group. Dimitrois K et al.20 also reported 2.4% cases of pneumothorax in the landmark group versus zero patients in the USG group.

Other complications

No other noticeable complication was noted in our study in either group.

In the study by Shrestha et al.11 and Dimitrios et al.20 also had no other complications.

Henjarrapa et al.16 noted 3.3 % cases of arrhythmias in USG group.

As reported in earlier studies, our study also point out that USG is more useful in the placement of IJV catheters. The USG technique not only clarify the relative position of the vein and it surrounding structures, but also help in identifying course of vein and the artery and their caliber thus infuse confidence to the operator.

LIMITATIONS

Our study did not make any comparison of various degrees of rotation of the head and the size of IJV. Length and thickness of neck has not studied.

CONCLUSION

This study has concluded that the USG guided technique is superior to the landmark guided technique for the central venous cannulation of the internal jugular vein. It can be used as the first line of cannulation to decrease complications and improve the outcome of the procedure.

REFERENCES


19. MFS Filho LP, de Souza KM, Palitot I, Magalhaes I. Comparison between ultrasound-guided and anatomic landmark...
