

Original research article

Comparison of Anatomical Landmark and Ultrasound Guided Technique for Internal Jugular Vein Cannulation in Patients for Major Surgeries

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Abstract

Background: The study was done to compare the technique for internal jugular vein cannulation by landmark and ultrasound guided in major surgeries in adult patients.

Materials and Methods: Approval of institutional review committee and informed consent were taken. 60 patients of ASA grade II OR III, scheduled for elective major gastrointestinal surgeries, cardiothoracic and vascular surgeries requiring central venous pressure monitoring or central venous access were included in this study and randomly divided in two groups (anatomical landmark group (LM group) and ultrasound guided (US group) of 30 each.

Results: The overall complication rate was higher in the landmark group than in the ultrasound-guided group. Carotid puncture rate and haematoma were more frequent in the landmark group than in the ultrasound-guided group. (The number of attempts for successful placement was significantly higher in the landmark group than in the ultrasound-guided group, which was accompanied by a significantly increased time observed in the landmark group. Although there were a higher number of attempts, longer access time, and a more frequent complication rate in the landmark group, success rate was found to be comparable between the two groups.

Conclusion: We conclude that use of ultrasound makes cannulation of the IJV a much safer technique, especially in high-risk patients, and leaves almost none to minimal chances of any complications. With experience, expertise and under real-time vision, the contra-indications to a central line insertion are almost nullified

Key words: Internal jugular vein cannulation, ultrasound guided technique

Introduction

Securing a central venous access is a fundamental clinical skill for managing patients in a wide variety of clinical situation in the operation theatre and the ICU for CVP monitoring, administration of fluids and cardiac supports, giving parenteral nutrition, haemodialysis, chemotherapy or due to difficulty in securing a peripheral venous access. Although a fairly common procedure, success in it requires knowledge of relevant anatomy, clinical condition

and existing comorbidities also need to be kept in mind^{1,2,3}. The veins that are usually cannulated are the internal jugular veins (IJV) in the neck, the subclavian veins under the clavicles and the femoral veins under inguinal ligaments, depending on the situation, need, indication and patient characteristics². Cannulation of the IJV is usually preferred because of its anatomical position and large diameter in the Trendelenburg position. Also, the minimal likelihood of an obstruction along its route to the right atrium facilitates the introduction of various sizes of catheters³. Traditionally, central venous catheterization is performed by using the anatomic landmark technique and there are many descriptions since 1966.⁴⁻⁷ Although the anatomical landmark techniques have been validated by various studies, they present quite a few mechanical complications during insertion. These complications include accidental carotid artery puncture, local hematoma formation, surrounding tissue damage and pneumothorax. Injuries to the brachial plexus, recurrent laryngeal nerve, cervical sympathetic chain and accidental tracheal puncture are other less frequently encountered complications⁸.

The benefits of ultrasound (US) guidance for locating the central veins was recognized as far back as 1978, the first report of ultrasound-guided CVC came into existence in 1987.⁹ In recent times, using ultrasonography either in preinsertion or in real time is accepted as remedy to reduce failure and malposition rate.¹⁰ It has been suggested that ultrasound guidance could improve the success rate, reduce the number of needle passes, and decrease complications. The use of ultrasound enables visualization of the targeted venous vessel and its anatomical relationship with surrounding structures and with the needle for catheterization. It allows detection of anatomical variations like vein and artery transposition and overlap.¹¹⁻¹² The use of ultrasound also enables visualization of correct position of vein, its size, patency and eventual thrombosis, which is especially useful in patients with difficult anatomical characteristics such as morbid obesity, cachexia and scars on the skin at the puncture site². Despite such advantages, ultrasound's widespread use has been hampered by the unavailability of equipment, added cost and the lack of trained personnel³. The purpose of our study was to compare the traditional anatomical landmark technique and ultrasound guidance technique to cannulate the IJV.

Materials and Methods

This was a randomised observational study conducted. Sixty adult patients of ASA physical status II and III undergoing elective major gastrointestinal, and cardiothoracic and vascular surgeries requiring central venous pressure monitoring or central venous access were included in the study. After obtaining written informed consent the patients were randomly assigned to two groups on a one to one ratio randomly. The right IJV cannulation was attempted.

- a) Landmark guided group (LM Group)
- b) Ultrasound guided group (US Group)

Inclusion Criteria

Adult patients with ASA Grade II and III posted for major surgeries.

Patients willing to enrol in the study.

Patients with age ≥ 18

Exclusion Criteria

1. Patients who do not give consent
2. Skin inflammation at insertion site
3. Altered coagulation profile (platelet count $< 50,000$ per cu mm, INR > 1.5)

4. Patients with known bleeding disorders
5. Prior catheterization
6. Subcutaneous emphysema
7. Patients undergoing radiation therapy

Preanaesthetic Assessment: All the patients underwent a thorough preanaesthetic check-up. Local part was examined and an informed written consent was taken.

Preparation: After taking the patient in the operation theatre, basic monitors: ECG, spo2 and non-invasive blood pressure were applied. A peripheral intravenous line was secured.

Equipment's Prepared:

A portable sterile tray containing:

Disposable syringes of 5,10 ml.
Disposable 23G 1.5 inch block needle
Povidone iodine, spirit and normal saline solutions
Sponge holding forceps
Sterile towel and towel clip
Drug injection Lignocaine 1% 5 ml
Four lumen central venous catheter 8fr 15 cm
Tegaderm
Needle holding forceps
Artery forceps
Ethilon 2-0 suture

Emergency resuscitation equipment were kept ready.

Ultrasound machine and its linear probe properly cleaned and aseptically prepared for the procedure.

Parameters:

Access time: Access time was defined as the time between the first skin puncture and the aspiration of venous blood into the syringe. In case of multiple attempts access time was calculated as follows the time interval of each attempt that is from skin puncture to withdrawal were added together to derive the fixed access time.

Overall success: Successful placement was defined by functional determinants (i.e., no difficulty in the infusion or aspiration of venous blood) and/or as the observation of the catheters in the proper position by X-ray. An unsuccessful attempt was declared when after skin puncture, needle advancement and needle withdrawal there wasn't a return of venous blood from the targeted vein.

After three unsuccessful attempts the procedure was terminated at the given site and declared unsuccessful.

Mechanical complications:

- 1) Carotid artery puncture - Arterial puncture was managed by removal of needle and application of firm pressure until hemostasis is achieved.
- 2) Haematoma-bigger than 1 cm in diameter on the skin access site.
- 3) Pneumothorax - Treated with tube thoracostomy if it was found to be significant or progressive or if more than 20% interface between lung and the chest wall was separated.
- 4) Catheter malposition

5) Double wall puncture – It is detected by appearance of venous blood while with drawing the needle.

All mechanical complications were evaluated clinically, by a chest x-ray and ultrasound when appropriate.

Landmark Guided Method

Patients were placed in the supine position with the head rotated to the left at a 30° angle in the Trendelenburg position.

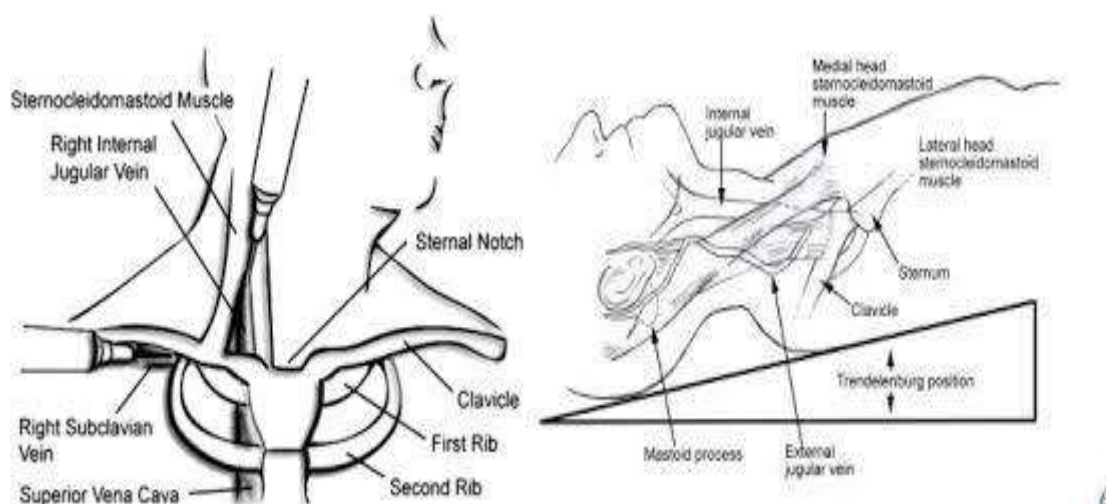
The skin was cleaned with povidone-iodine before the placement of sterile drapes.

The fingers of the left hand were used to palpate the two heads of the sternocleidomastoid and the carotid pulse.

After infiltration with 1% lignocaine, the IJV was first located at the apex of the triangle formed by the clavicle and the two heads of the sternocleidomastoid muscle with a 23 G 1.5 inch finder needle attached to a 5 ml syringe held at an angle of 45° directed toward the ipsilateral nipple with continuous aspiration.

After the successful location, the finder needle was withdrawn and the venous puncture was performed using an 18-gauge puncture needle.

The catheterization was completed using the modified Seldinger technique with four lumen central venous catheter 15 cm 8 Fr.



Real Time Ultrasound Guided Method

The area was prepared as described in the landmark technique above.

A standard two dimensional real time B mode imaging obtained with a portable unit and 7.5 MHz linear array ultrasound probe covered with a ultrasound gel and wrapped in a sterile sheath. Short axis technique “out of plane” approach was used. The probe was placed over the patient's right anterior triangle of the neck. The IJV (thin walled, compressible, non-pulsatile) was visualized in both longitudinal and transverse sections. IJV was identified as a thin-walled structure that was easily compressible by external pressure by the probe. It was mostly anterolateral to the carotid artery (thick walled, non-compressible, pulsatile).

The depth, calibre of the IJV, patency and compressibility were noted.

After infiltration with 1% lignocaine, the cannulation needle inserted under US guidance and return of venous blood into syringe.

The vein was cannulated by modified Seldingers technique with four lumen central venous catheter 15cm 8 Fr.

Statistics

Results were statistically analyzed by unpaired t-test with $p < 0.05$ considered statistically significant. Data were presented as mean value and mean+SD.

Results

The characteristics of the 60 patients studied are summarized in table 1

Table 1: Characteristics Of Patients

	The LM group (n=30)	The US group (n=30)
Age	50.1±15.70	53.1±15.05
Gender(M:F)	22:8	20:10
BMI	21.53 ± 1.66	21.83 ± 1.43

Data are presented as mean ± SD or %.

Baseline characteristics in both the groups were comparable with no significant difference in terms of age, gender and body mass index (BMI).

Table 2: Types Of Surgeries

Surgeries	The LM group	The US group
Cardiothoracic & vascular	15	17
Gastrointestinal	15	13

In our study, in the landmark group, 15 patients were undergone cardiothoracic and vascular surgeries while 15 patients were undergone gastrointestinal surgeries. In ultrasound group, 17 patients were undergone cardiothoracic & vascular surgeries while 13 patients undergone gastrointestinal surgeries

Table 3: Access Time

Access Time	The LM group	The US group	P-value
Mean	19.30	9.63	<0.0001
SD	8.85	1.85	

P value < 0.05, so this difference is extremely statistically significant.

Access time was significantly higher in landmark group than ultrasound group.

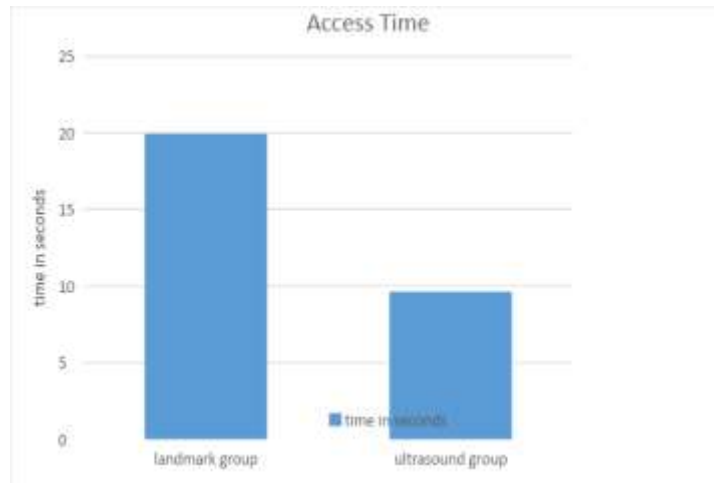


Table 4: Success On First Attempt

	The LM group	The US group
1 st attempt	20 (66.67%)	28 (93.33%)
2 nd attempt	7 (23.34%)	2 (6.67%)
3 rd attempt	3(10%)	0

In ultrasound group, success on first attempt was 93.33% compared to 66.67% in landmark group which is statistically significant. (P<0.05)

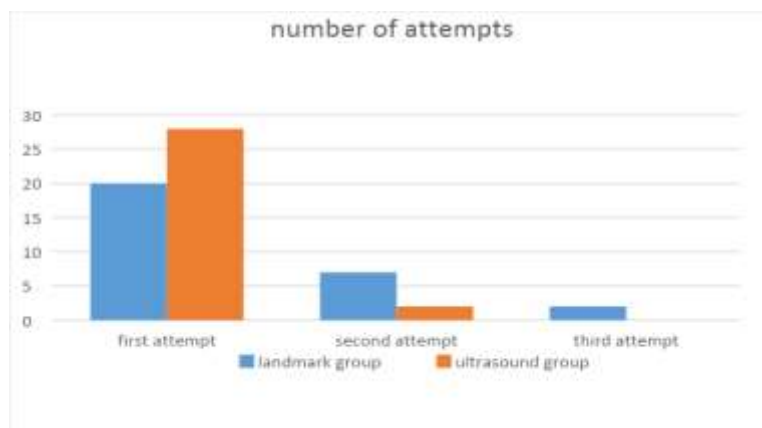


Table 5: Number Of Attempts

Attempts	The LM group	The US group	P-value
Mean	1.43	1.06	<0.0001
SD	0.66	0.24	

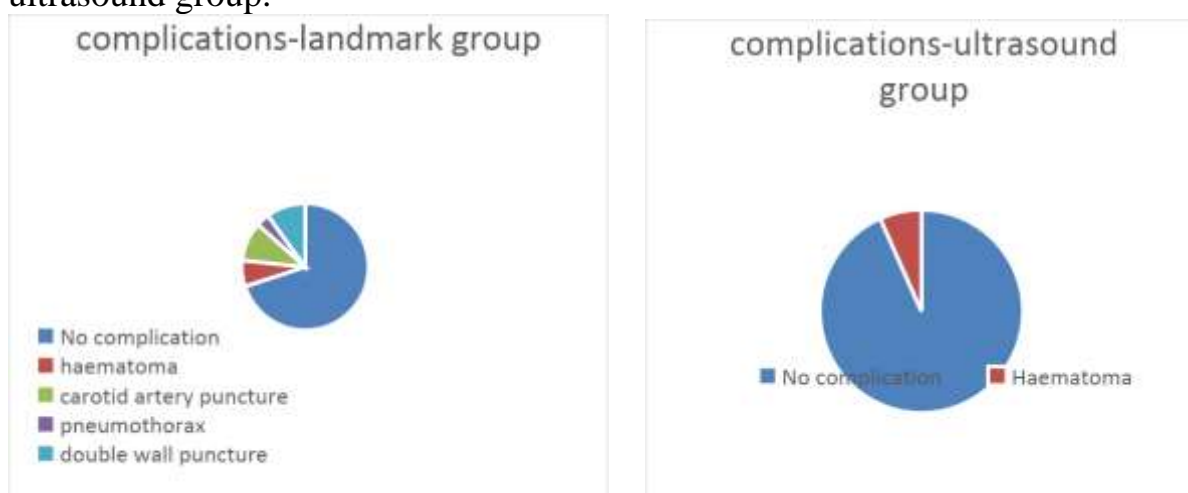
P value <0.05 so this difference is statistically significant. Attempts were higher in landmark group compared to ultrasound group.

Table 6: Complications

	The LM group	The US group
Total number of complications	9 (30%)	2 (6.67%)
Hematoma	2 (6.67%)	1(3.33%)
Carotid artery puncture	3 (10%)	0
Pneumothorax	1 (3.33%)	0
Double wall puncture	3 (10%)	1(3.33%)

P value < 0.05. This difference is statistically significant.

Total number of complications were higher in landmark group compared to ultrasound group.



Discussion:

During the last two decades, central venous catheterization has been increasingly used in clinical practice for various reasons. Percutaneous techniques revolutionized vascular cannulation. They essentially eliminated the need for open cut-down procedures and the associated wound-related morbidity, but percutaneous techniques left the operating physician exclusively reliant upon the relationships between surface anatomic landmarks and the underlying deep anatomic structures.²³ However, despite increased experience, the classical anatomic landmark method is associated with a small but potentially significant rate of morbidity mostly in view of mechanical complications, which usually occur during insertion and are intimately related to the anatomical relationships of the central veins.^{18,24}

Using ultrasound, the needle is advanced under real time ultrasonographic guidance and allows safe introduction of needle into the internal jugular vein.

The surrounding vessels and tissues are also visualised and hence accidental punctures and tissue injury are avoided. Also, using ultrasound the depth at which

the IJV is situated can be estimated which in turn helps to avoid deep needle punctures and hence reduces the chances of puncturing the pleura.

In our study, we randomly divided 60 selected patients who were undergoing major cardiothoracic and gastrointestinal surgeries into anatomical landmark group (LM group) and ultrasound guided group (US group) and compared both techniques.

Age, Gender and BMI were comparable in both the groups with no significant difference.

Access Time

In terms of access time, we found a statistically significant difference in access time between both the groups. Access time was longer in group landmark as compared to group ultrasound.

Mean access time was 19.30 ± 8.85 seconds in landmark group and 9.63 ± 1.85 seconds in ultrasound group.

These findings are comparable to the study of 70 patients by Meenhas Oravil Kunhahamed et al²² in which the mean start to flash time for the anatomical landmark group was 16.59 ± 10.67 seconds and $4.86 \text{ s} \pm 2.18$ seconds in the ultrasound group.

Furthermore, Dimitrios Karakitos et al¹⁷ also concluded that access time was longer in landmark group 44 ± 95.4 seconds than ultrasound group 17.1 ± 16.5 seconds in a study that he conducted in 450 patients.

Similarly Hamidreza Karimi-Sari, et al²¹ (2014), Teichgräber¹⁵ et al (1998), M Slama et al¹³ (1997) all mentioned that when compared to landmark technique, ultrasound technique has a faster access time.

Attempts

In regards to the number of attempts, in our study, the average number of attempts for catheterization in landmark group was 1.43 ± 0.66 and in ultrasound group was 1.06 ± 0.24 . It was a statistically significant difference ($P < 0.05$). In the landmark group the success on first attempt was 66.67% and in ultrasound group it was 93.33% which was statistically significant ($P < 0.05$).

Darko Sazdov et al² concluded in their study of 400 patients that in the landmark group the success on first attempt was 60.5% and in ultrasound group it was 77%. The average number of attempts for successful catheterization in the landmark

group was 1.52 and in the ultrasound group was 1.25. There was a statistically significant difference in the average number of attempts between groups for $p < 0.05$. The results of this study are comparable to our study.

Similarly, In Gurkan Turker et al³ (2009) reported that average number of attempts in LM group was 1.42 ± 0.92 and US group was 1.08 ± 0.33 in his study of 380 patients.

Agarwal et al¹⁹ (2009), Konstantinos Serafimidis et al¹⁸ (2009), Dimitrios Karakitsos et al¹⁷ (2006) all concluded that number of attempts are lower with ultrasound technique than landmark technique.

Meenhas Oravil Kunhahamed et al²² reported in their study of 70 patients that the catheter was placed on the first attempt in 17 (48.6%) patients in the anatomical landmark group and 32 (91.4%) patients in the USG group.

Shrestha BR et al⁹ (2011), Bart G. Denys et al¹³ (1993) reported that success on first attempt was higher in ultrasound than landmark technique. These results correspond with our study.

In both groups 30/30 (100%) of patients were successfully catheterized. These findings are similar to Turker et al³ study of 380 patients between the two groups (LM group=97.36%, US group=99.47%). Similarly, Koroglu et al¹⁶ reported comparable success rate in their study of 80 patients (anatomical landmark technique=97.5%, ultrasound guided technique=100%).

Complications

In this study, the overall complications were higher in the landmark group compared to the ultrasound group (30% and 6.67%, respectively) which is statistically significant ($P < 0.05$). The carotid artery puncture (10%) and double wall puncture (10%) were the most frequent complications in the landmark group followed by haematoma (6.67%) and pneumothorax (3.33%). Similarly, Shrestha BR et al⁹ (2015) concluded in their study of 120 patients that overall complications are higher in landmark than ultrasound technique. There were 6 carotid artery punctures (10%) and 5 (8%) haematomas in the landmark group and 2 carotid artery punctures (3%) and 1 haematoma (2%) in the USG group.

Peris, Adriano et al²⁰ (2010) reported that the ultrasound group showed a significantly lower arterial puncture rate (1.4% vs. 6.9%), fewer wire advancement difficulties (3.4% vs. 11.2%), lower subcutaneous haematoma rate (1.6% vs. 8.2%), and a lower rate of pneumothorax (1.3% vs. 3.1%) when compared with the landmark group ($P < 0.001$). Results of this study are comparable to our study.

Teichgräber¹⁵ et al (1998), Konstantinos Serafimidis et al¹⁸ (2009), Dimitrios Karakitos et al¹⁷(2009), Koroglu M et al¹⁶(2006), Bart G. Denys et al¹³(1993) all mentioned that complications were higher in landmark technique than ultrasound technique which correspond to our study.

Traditionally for the landmark method, visible and palpable external landmarks with known relation with the targeted vessel are used to determine the puncture site on the skin.²⁴ This method is associated with complications that result in increased morbidity, longer hospital stay, increased expenses and mortality.²³

Vascular anomalies and anatomic variations of the IJV and surrounding tissues have been observed in up to 36% of patients.²⁵ Ultrasound identifies the vein size and location, anomalies, and vessel patency, also avoiding futile attempts in patients with absent or thrombosed veins and congenital anomalies.

The issues created by the close proximity of the carotid artery to the internal jugular vein are most efficaciously dealt with ultrasound localization of the carotid artery and internal jugular vein in real time during venipuncture. Ultrasonographic imaging visually differentiates the internal jugular vein and common carotid artery, facilitates venipuncture rather than arterial puncture, guards against through-and-through puncture of the internal jugular vein, and prevents deep passage of a needle into deep cervical and thoracic structures.²³

The safety of the ultrasound guided technique may be especially important in selected group of patients, such as un-cooperative or very obese patients (where the location of the anatomic landmarks may be difficult), in patients with increased risk for pneumothorax (patients under mechanical ventilation or with chronic obstructive pulmonary disease), but also in patients with haematological or neoplastic disease (where catheter placement involves an additional risk due to disease or treatment-related thrombocytopenia or other disorders of haemostasis).^{26,27,28}

Obviously, the increased success rate and safety result in significant decrease of patient's discomfort, and thus this method is much more appealing for both the patient as well as the clinician.¹⁸

Conclusion:

We prospectively evaluated an ultrasound-guided method in 30 patients undergoing internal jugular venous cannulation and compared the results with 30 patients whom an external landmark-guided technique was used. Cannulation of the internal jugular vein was achieved in all patients .

Hence, Ultrasound-guided cannulation of the internal jugular vein significantly improves success rate,decreases access time, and reduces complication rate.

These results suggest that this technique may be preferred in complicated cases or when access problems are anticipated.

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