

Comparison of catheterization of internal jugular vein by ultrasound guided versus landmark approach IN I.C.U. patients

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Abstract

Introduction: Central venous line placement is one of the essential procedures in the treatment of critically ill patients admitted in the intensive care unit. Central venous catheterization is required not only for providing a route for delivery of the caustic or critical medications but it also allows for the measurement of central venous pressure. Being an invasive procedure it has a learning curve and is associated with many complications. Hence, we conducted the study comparing catheterization of internal jugular vein by ultrasound guided versus landmark approach, with respect to the ease of insertion and related complications in Intensive Care Unit (I.C.U.) patients.

Materials and Methods: 150 patients admitted in the I.C.U, fulfilling the inclusion criteria were divided into two groups based on computer generated randomization table namely: group A (landmark technique) and group B (USG technique) comprising of 75 patients in each group. In landmark approach, the internal jugular vein was located at the apex of triangle formed by the sterna and clavicular heads of sternocleidomastoid muscle and needle was directed towards the ipsilateral nipple when advanced through skin, lateral to the carotid artery pulsations with artery being pushed medially. In USG guided approach, the linear USG probe of 7 MHz connected to a real-time Kontron Medical ultrasound unit, was used with standard two-dimensional (2D) ultrasound imaging to identify the IJV. Catheterization was performed real-time by placing the transducer of the ultrasound parallel and superior to clavicle, over the groove between the two heads of the sternocleidomastoid muscle (SAX view). A post-procedure x-ray of chest was done as early as possible to assess the placement of CVC and rule out any complication.

Results: The two groups were comparable in age, sex and body mass index. There was no statistically significant difference in the mean number of attempts taken for catheterization of IJV between the two groups (p-value=0.124). However, the mean time taken for cannulation of IJV was found to be significantly lower in the USG group as compared to the landmark group (p-value=0.03). The overall rate of complications was significantly higher in group A (p=0.012).

Conclusion: Ultrasonography guidance significantly reduced the total procedural time and the rate of complications during internal jugular vein cannulation compared to the landmark technique.

Keywords: Internal jugular vein, Central venous catheterization, Landmark approach, Ultrasound guided approach.

Introduction

Central venous access is defined as placement of a catheter into great venous vessels of the body.¹ Central venous catheterization (CVC) is performed for various purposes, some of them are hemodynamic monitoring, administration of blood products and irritant drugs (like, chemotherapy and antibiotics), haemodialysis, total parenteral nutrition (TPN) and last but not the least volume resuscitation.

The commonest sites of central venous catheterization are the internal jugular vein, subclavian vein, femoral vein, or arm veins using peripherally inserted central catheters (PICC) and the choice of access route depend on various factors. Central venous catheterization is classically performed by puncturing a central vein and introducing the needle along the long axis of the vein by using surface anatomical landmarks of the respective vein. This is known as the 'anatomical approach'.²

It has been advocated that ultrasound (USG) guidance could be great benefit in placement of CVC by improving the rate of success, reducing the number of needle punctures, and also decreasing the rate of

complications. Although USG guidance seems safer compared to the landmark technique, we still surface great number of difficulties most of which are related to technical problems some of which are lack of specifically designed USG devices or sterile scanner manipulation, unavailability of equipment and lack of trained manpower.⁴

Ultrasound guidance can be broadly divided into two namely static and dynamic. In static ultrasound guidance the target vein is located with the help of ultrasound probe prior to its puncture whereas in dynamic ultrasound guidance the target vein and its surrounding anatomical structures are in continuous vision at the time of puncture providing real time imaging of the procedure visualized dynamic ultrasound guidance can be either in short axis view (SAX) in which one visualizes the cross sectional image of the vessels or long axis view (LAX) in which the entire length of the vessel can be visualized on the monitor. The major benefit with LAX is that one can visualize the needle tip at all time during the entire time of procedure.⁵

Therefore, we conducted the study comparing catheterization of internal jugular vein by ultrasound guided versus landmark approach, with respect to the ease of insertion and related complications in Intensive Care Unit (I.C.U.) patients.

Materials and Methods

This prospective study was conducted after prior approval from the Institutional Ethical Committee; in 150 patients requiring central venous cannulation in I.C.U. Patients were included in the study after taking prior written and informed consent from the relative of the patient. Based on the computer generated randomization table, the patients were randomly allocated into two groups namely: group A (landmark technique) and group B (USG technique) via computer generated randomization table comprising 75 patients in each group.

All Patients between 18-60 years of age of either sex admitted in the ICU were included in the study except. Patients excluded from the study were those with history of central venous catheterization within last 15 days, any anatomical deformity, infection at the puncture site, emergency or life threatening condition, bleeding disorder or coagulopathy, age < 18 years, BMI ≥ 35 kg/m² and relatives refusal.

All catheterizations in the USG technique group (group B) were done by experienced operator who had undergone training in USG guided CVC by trained ultrasonologists with ≥ 6 months of experience in I.C.U and experience of least 25 successful central venous cannulations. In group A, the central line cannulation was done by the anaesthetist who filled the criteria for group B also.

Patient fulfilling the inclusion criteria was placed supine with neck extension and 30° trendelenburg position was given. Patient was sedated as per the operator's preference and the clinical condition of the patient. Sterile aseptic precautions were taken. A 7Fr, 16 cm triple lumen CVC was used and inserted via Seldinger's technique.

In landmark approach, the operator located the internal jugular vein at the apex of triangle formed by the clavicular and sterna heads of sternocleidomastoid muscle. After palpating the carotid artery and pushing it medially, a 22G finder needle with 5ml syringe loaded with heparin saline attached to it was advanced through the skin making an angle of 45° directed towards the ipsilateral nipple by applying a constant negative pressure. The entry of venous blood into the syringe confirmed the correct placement of needle into internal jugular vein and it was then used to guide a 7cm, 18G introducer needle into the vessel. After successful aspiration of venous blood through the introducer needle, a guidewire was threaded across the lumen of the needle into the vein, and the needle was then gently removed ensuring that the guidewire was well in place. A small incision was placed on the skin at the point of

entry of the guidewire and the dilator passed over the guidewire carefully. Thereafter the dilator was withdrawn and the catheter was threaded over the guidewire and was advanced into the IJV. In USG guided approach, the linear USG probe of 7 MHz covered with sterile sheath was connected to real-time Kontron Medical ultrasound unit, and after applying sterile betadine it was used for identification of internal jugular vein. We also evaluated the patency, compressibility and any pre-existing thrombus in the internal jugular vein. Catheterization was performed under visualization of IJV by placing the transducer parallel and superior to clavicle, between the sternal and clavicular heads of the sternocleidomastoid muscle (SAX view). Carotid artery is identified as circular, pulsatile and non-compressible structure on transverse section; whereas IJV appears as oval, non-pulsatile but compressible structure. An 18G introducer needle was connected to 5 ml syringe filled with heparinised saline and was introduced making an angle of 45° to the skin under real time USG guidance. After successful aspiration of venous blood, the guidewire was threaded through the needle into the vein, and the needle was gently removed. A small incision was placed over the skin at the site of guidewire and the dilator was carefully passed over the guidewire. The dilator was gently removed and the catheter was then threaded over the wire and advanced into the IJV. All 3 ports were checked for backflow of blood and flushed. The CVC was then sutured and aseptic dressing done. A post-procedure x-ray was done at the earliest to assess placement of CVC and rule out any complication.

Parameters studied during the procedure were:

1. Ease of insertion of procedure with two techniques
 - a. Time taken for catheterization- defined as the number of seconds taken from holding the needle till placement of guidewire
 - b. Number of attempts taken for the successful placement of catheter
2. Complications
 - a. ECG changes like any form of arrhythmias which were treated as per the standard AHA guidelines.
 - b. Any local swelling or hematoma formation which was treated by applying a compression bandage and observing the patient for any haemodynamic instability.
 - c. Accidental carotid puncture which was managed by applying pressure over the vessel for 5 minutes and thereafter applying a pressure bandage.
 - d. Bleeding.
 - e. Pneumothorax or hemothorax which was observed with the help of the ventilator parameter like any increase in airway pressure or any sudden haemodynamic instability. Chest X-ray was also done which could help in the diagnosis and if observed then and intercostal drain was inserted.
 - f. Malpositioning of CVC which was detected on the x-ray and the catheter was pulled out to achieve

right position. If the catheter was grossly malpositioned, it was removed and the dressing was done.

We also observed for any resistance encountered during passage of guidewire or catheter.

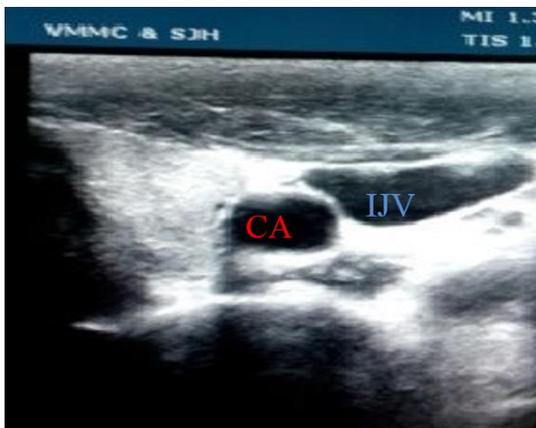


Fig. 1: 2D USG imaging showing CA and IJV. CA appears round, thick walled and is pulsatile and non-compressible, whereas IJV is oval shaped, thin walled and is non-pulsatile but compressible



Fig. 2: Linear USG probe covered with ultrasonic gel and wrapped in sterile sheath used for real time visualization and cannulation of right IJV

Results

The two groups were comparable in age, sex, BMI. In our study the mean number of attempts taken for successful catheterization were comparable among two groups (p-value=0.124, 95% CI= -0.055 to +0.450). However, the mean time taken for successful cannulation was significantly shorter in USG group as compared to landmark group (p-value=0.03, 95% CI= +2.159 to +49.961). Difference in overall mechanical complications was not statistically significant in two groups (p-value= 0.121, 95% CI= -0.082 to +0.189), but a statistically significant difference was observed in hematoma formation which was 20% and 8% respectively in landmark and USG groups (p-value=0.016).

Table 1: Comparing number of attempts for study groups

| | Landmark Group(A) (n=75) | USG Group(B) (n=75) | p-value |
|---------------------------------|--------------------------|---------------------|---------|
| Min. No. of attempts | 1 | 1 | |
| Max no. of Attempts | 4 | 3 | |
| Mean no. of Attempts \pm SD | 1.64 \pm 0.88 | 1.45 \pm 0.64 | 0.124 |
| Cases Requiring > 1 Attempt (%) | 33(44) | 28(37.33) | 0.406 |

Table 2: Comparing time for catheterization for study groups

| | Landmark Group(A) (n=75) | USG Group(B) (n=75) | p-value |
|---|--------------------------|---------------------|---------|
| Max. Time (Sec) | 410 | 281 | |
| Min. Time (Sec) | 29 | 25 | |
| Mean Time \pm SD (Sec) Per Case | 95.4 \pm 88.24 | 69.16 \pm 54.94 | 0.03 |
| Catheterizations Performed \leq 1 Minute (%) | 58.66 | 69.33 | |
| Catheterizations Performed \leq 2 Minutes (%) | 78.66 | 86.66 | |

Table 3: Comparing complications in study groups

| | Landmark Group(A) (n=75) | USG Group(B) (n=75) | p-value |
|---|--------------------------|---------------------|---------|
| ECG changes (%) | 6(5) | 3(4) | 0.494 |
| Hematoma formation (%) | 7(9) | 3(2) | 0.016 |
| Carotid artery puncture (%) | 4(5.3) | 3(4) | 0.190 |
| Pneumothorax (%) | 0(0) | 0(0) | 1 |
| Catheter related blood stream infection (%) | 1(1.1) | 1(1.1) | 1 |
| Thrombus formation (%) | 1(1.1) | 0(0) | <0.001 |

Discussion

Over decades anaesthesiologists have been performing various interventional procedures with anatomical landmarks as the only guiding light with variable success rates, risks, complications and consequences of those complications. Ultrasound imaging has been recently introduced in the field of anesthesiology, critical care and pain to perform various procedures with better precision, improved success rates and reduces the associated risks and complications. Ultrasound has shown promising results as a tool to offer excellent guidance for difficult venous access, epidural space localization, identifying the nerve plexuses for nerve blocks, and also in transesophageal echocardiography.⁷

National Institute for Clinical Excellence, United Kingdom (NICE, U.K.) recommended 2-D imaging USG guidance as the preferred method for insertion of CVC into the IJV in adults and children in elective situations. It also recommends that all those involved in placing CVCs using 2-D imaging USG guidance should undertake appropriate training to achieve competence.⁴

To acquire expertise with USG-guided cannulation one requires diligent training and experience as even with the use of USG guided central line cannulations complications such as carotid artery dissection has been described in literature.⁸ USG does not guarantee decreased procedural complications when it is used by an inexperienced person. However, when the operator becomes more experienced (>25 insertions) the addition of ultrasound significantly reduces procedural-related complications. Hence with respect to this learning curve, sufficient training and exposure must be provided for trainees to become familiar with the technique of CVC insertion itself before a possible benefit of the addition of USG technique can be observed.⁹

In our study also, we observed that use of USG guidance provides a faster access than conventional landmark approach though difference in success rate and mean number of attempts are not statistically significant. Balls et al in their study found that overall successful placement rate did not vary according to the use of USG guidance.¹⁰ Many other studies¹¹⁻²⁰ have observed significant reduction in rate of hematoma formation and carotid artery puncture and a higher success rate with USG guidance. Wu et al observed in their meta-analysis that real time USG guidance

significantly reduced the risk of cannulation failure (RR = 0.18, $P < 0.001$) and reduce the occurrence of clinical adverse events, including the risk of arterial puncture (RR = 0.25, $P < 0.001$), hematoma (RR = 0.30, $P < 0.001$), pneumothorax (RR = 0.21, $P = 0.014$), and hemothorax (RR = 0.10, $P = 0.007$).¹¹ Agarwal et al also observed the mean time to successful aspiration of venous blood was lesser in group undergoing USG guided IJV catheterization as compared to the landmark

approach group (145 secs vs. 176.43 secs.) in I.C.U. patients. The mean number of attempts required in the first group was much less than the second group (1.20 vs. 1.53). Also the landmark group encountered arterial puncture (10%) and pneumothorax (2.5%) whereas no such complications were observed in USG group.¹² But in our study, though rate of hematoma formation was significantly reduced, but there was no statistically significant difference observed in the incidence of carotid artery puncture (5.3% and 4% in landmark group and USG guided group respectively, $p=0.190$). Many studies in pediatric patients²¹⁻²³ also concluded that real-time USG guidance could enhance procedural efficacy and safety of IJV catheterization in pediatric age group where central venous cannulation is considered more difficult as compared with adults. Dodge et al assessed the impact of simulation training on CVC insertion success rate and observed that USG guidance, both dynamic as well as static, for CVC insertion were associated with improved in-hospital first cannulation rates and overall success rates of insertions by junior residents.²⁴

There were two cases in our study where cannulation was not successful by landmark technique and USG guidance was immediately resorted to and successful cannulation of IJV was then done. Similarly, there was one case where initially USG guided cannulation failed due to difficulty in placement of guidewire followed by hematoma formation and then landmark approach was used after an interval of 2 hours and successful cannulation could then be done. Hence no single approach is perfect/foolproof, and one should be ready to shift from one approach to another if need arise. USG guided central venous cannulation does have the potential for deskilling in the landmark technique that may be required in emergency situations or when equipment is not available.²⁵

Conclusion

Ultrasonography provides the benefit of real time visualization of the anatomical structures at the time of procedure and significantly reduces the total procedural time. However the procedural time also depends on the person performing the procedure as the person performing it must not only be well versed with sonoanatomy but should have adequate training too. We also found that USG significantly reduced the rate of complications compared to the landmark technique. Landmark technique is a blind technique which because of its very nature it is likely to have higher rate of complications.

However, one must not forget that the operator who is more experienced in one approach will have higher success rate and lower complications using that approach as compared to the newer approach in which he/she lacks experience. The benefit of ultrasonography can only be availed with the complete knowledge of

sonoanatomy and sufficient hands-on experience of the operator.

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