ORIGINAL ARTICLE

Ultrasound Guided Internal Jugular Venous Cannulation: Comparison with Land-Mark Technique

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Abstract

Objective: To compare real-time ultrasonography-guided technique versus the traditional land-mark technique for internal Jugular venous cannulation.

Study Design: Randomized controlled trial.

Place and Duration of Study: Department of Anaesthesia, Combined Military Hospital, Rawalpindi, from September 2013 to July 2014.

Methodology: A total of 200 patients who required internal jugular vein cannulation were randomly assigned using either real-time ultrasound-guided technique or land-mark technique. Access time, number of attempts until successful cannulation, complications and the demographics of each patient were recorded.

Results: Access time was significantly less in real-time ultrasound group (34.95 ± 11.47 vs. 146.59 ± 40.20 seconds, $p < 0.001$). Cannulation was performed in first attempt in 99% of patients in ultrasound group as compared to 89% of land-mark group. Complication rate was significantly higher in the land-mark group than in the ultrasound-guided group. Carotid artery puncture rate (9% vs. 1%) and haematoma formation (7% vs. 0%) were more frequent in the land-mark group than in the ultrasound-guided group. Brachial plexus irritation was also more in land-mark group (6% vs. 0%).

Conclusion: Access time, failure rate and procedure related complications are reduced when real-time ultrasonography is used to cannulate internal Jugular vein.

Key Words: *Jugular vein. Central venous cannulation. Ultrasonography.*

INTRODUCTION

Cannulation of Internal Jugular Vein (IJV) is commonly performed to obtain venous access for procedures such as central venous pressure monitoring, the insertion of a pulmonary artery catheter, the administration of drugs such as vasopressors, inotropes, antibiotics, and chemotherapeutic agents as well as long-term administration of fluids, total parenteral nutrition and haemodialysis.[1,2] Mostly cannulation is done as a blind procedure utilizing anatomic land-marks. The success of this technique is highly dependent on physician's knowledge of anatomy and clinical experience.[3] Over the past decade, the increased use of ultrasonography to guide internal jugular vein cannulation has improved success rates, reduced the time required to perform the procedure, and reduced complications. Ultrasonography is a non-invasive, non-ionizing form of imaging that is safe for use in patients of all ages and in women who are pregnant. Use of ultrasonography to cannulate IJV offers certain benefits like, visualization of vascular structures, optimal needle placement, protection against puncture of the posterior wall of the IJV, accurate placement of catheter inside the IJV, confirmation of the guide wire inside the IJV, shorter performance time, lower number of attempts and lower complications rate.[4,5] Ultrasonographic-guided CVC insertion is also proved to be a better option than land-mark techniques in patients having haematological malignancies and in neonates and infants.[6,7]

Ultrasound guidance for IJV cannulation has gained popularity among practitioners. In some patients, surface land-marks can be difficult or even impossible to locate due to modified surface anatomy, radiotherapy, obesity, edema, burns, or prior surgery. Success with insertion of central venous catheters also depends on the size of the internal jugular vein, the patient's blood volume, positioning, head rotation, pressure on the skin, and presence of trauma.[8] For all of these reasons and despite the operator's possible extensive experience, it is sometimes impossible to puncture the vein. With the help of real-time ultrasonography, the practitioner can actually 'see' the vein while cannulation and the procedure no more remain 'blind'.

The aim of this study was to compare the outcomes associated with the IJV cannulation by real-time ultrasonography versus land-mark technique.

METHODOLOGY

The operators performing the jugular venous catheterizations were 6 fellows and 4 residents of our anaesthesia department, who had minimum of 3 years

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of experience in central venous catheterization without ultrasound and experience of more than 25 independent ultrasound-guided IJV catheterizations. All operators also attended a hands-on workshop on ultrasound guided central venous catheterizations conducted by the authors' department. After approval from hospital ethics committee, 200 adult patients were randomly selected (alternate patient) who required IJV catheterization. All the patients were evaluated before the procedure. Written informed consent was taken from all patients. Platelet count above 100,000 and normal coagulation profile was pre-requisite for the study. Patients with local or systemic infection, known vascular abnormalities, untreated coagulopathy were excluded from the study. A resident was assigned to collect all the data.

During procedure, patients were awake and spontaneously breathing. With the patient in the 30° Trendelenburg position, a shoulder roll was placed to extend the neck, which was rotated to left side to expose the puncture site. Informed consent was obtained in all cases. Pulse oximetry, blood pressure and cardiac monitoring with Truscope Classic (Schiller Switzerland) were performed during the procedure. An 18-guage central venous catheter was used with Seldinger technique in both groups. The operators and their assistants were fully prepared and drapped as per standard aseptic precautions. In the land-mark technique, the skin was cleaned with povidone-iodine and then sterile drapes were placed. After infiltration with 1% lignocaine, the CVP needle was advanced through the skin at a 45° angle in the direction of the right nipple. The return of venous blood into the syringe confirmed entry into the vessel, a guide-wire was then placed through the needle into the vein, and the needle was removed. A central venous catheter was placed over the wire and advanced into the IJV. In the real-time ultrasonography group, the operators and patients were aseptically prepared. Internal jugular vein was located with the help of ultrasound 10 MHz probe. The skin was infiltrated with 1% lignocaine, the wheel of subcutaneous lignocaine was visualized with the ultrasound as an enlarging hypoechoic area. Vein was compressible, non-pulsatile, and distensible by the Trendelenberg position or the Valsalva maneuver. When the needle appeared to be in the vessel, evidenced by the ultrasound and the return of venous blood into the syringe, a guide-wire was placed through the needle into the vein (Figure 2) and the needle was removed. A central venous catheter (Arrow International, USA) was placed over the wire and advanced into the IJV. A chest X-ray was taken within one hour of procedure to document the final position of the catheter as well as to look for complications like pneumothorax.

The access time, number of attempts till successful placement of catheter and complications were recorded. Access time was defined as the time between the first skin puncture and the aspiration of venous blood into the syringe in seconds. The number of attempts to achieve a successful puncture was also measured. Complications, including arterial puncture, haematoma, haemothorax, irritation of brachial plexus and pneumothorax were recorded. Brachial plexus irritation was defined as persistent pain or tingling sensation on ipsilateral side of IJV cannulation. Patients' demographics were also documented. Sample size was calculated using on-line WHO sample size calculator. Power of test was kept 99% and level of significance 5%. Calculator gave us sample size of 180. To be on the safe side we decided to keep our sample size to 200. Data was entered in IBM SPSS statistical software version 20. We used independent sample t-test for quantitative data and Fisher's exact test for qualitative data. P-value < 0.05 was taken as statistically significant.

RESULTS

In this study, cannulation of the internal jugular vein was achieved in all 100 patients using real-time ultrasonography and in 96 patients using the land-mark technique. The vein was entered on the first attempt in 99 patients (99%) of ultrasound-group and in 89

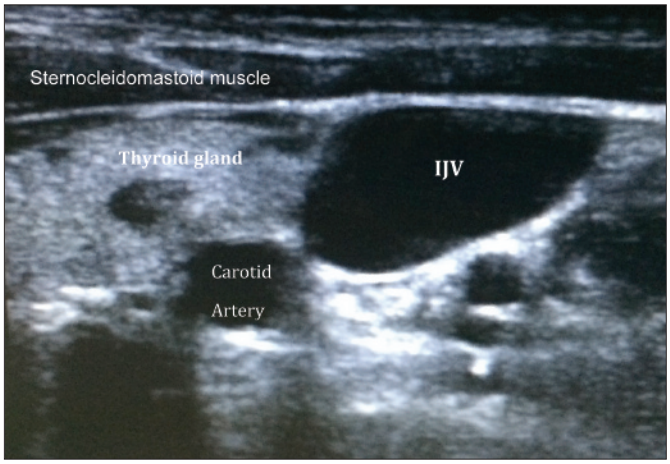

Figure 1: Ultrasonographic image of internal jugular vein and its relation to surrounding structures in neck.

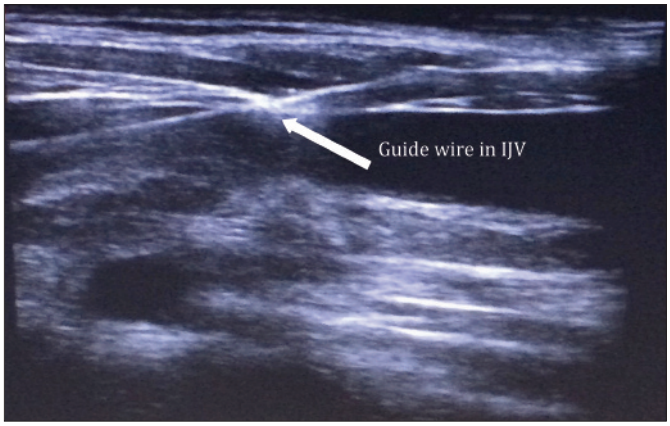

Figure 2: Guide wire in internal jugular vein (longitudinal view).

Table I: Patient demographics.

Group (n=100)	Ultrasound group (n=100)	Land-mark
Age (years) ±SD	44.25 ± 14.43	48.59 ± 14.57
Gender (M/F)	74/26	81/19
Right or left IJV (R/L)	96/4	96/4

Table II: Access time, number of attempts and complications.

	Ultrasound group (n=100)	Land-mark group (n=100)	p-value
Access time (seconds)	34.95 ± 11.47	146.59 ± 40.20	0.001
Success in 1st attempt	99 (99%)	89 (89%)	0.027
Success in 2nd attempt	1 (1%)	7 (7%)	0.065
Carotid artery puncture	1 (1%)	9 (9%)	0.009
Irritation of brachial plexus	0	6 (6%)	0.024
Haematoma	0	7 (7%)	0.014
Haemothorax	0	0	-
Pneumothorax	0	0	-

patients (89%) of land-mark-group (p=0.027) which was statistically significant. Second attempt was successful in one patient of ultrasound-group and in 7 patients (7%) of land-mark-group (p=0.065) which was also significant statistically. Four patients of land-mark-group were not cannulated even on the second attempt and we successfully cannulated them using ultrasound. Average access time (skin to vein) was 34.95 ± 11.47 seconds by the ultrasound approach and it was significantly longer (146.59 ± 40.20 seconds) in the land-mark group ($p < 0.001$). Using ultrasound, puncture of the carotid artery occurred in just one patient (1%), while it was significantly higher (9%) in land-mark technique (p=0.009). In the ultrasound group none of the patient developed brachial plexus irritation or haematoma. While in land-mark group, brachial plexus irritation occurred in 6% of patients (p=0.024) and haematoma in 7% of patients (p=0.014), both significant statistically. Haemothorax and pneumothorax did not occur in either of the groups.

DISCUSSION

Central venous line cannulations are commonly performed procedures but their use may be associated with adverse effects that are both hazardous to patients and expensive to treat.[9] Central venous cannulation of the IJV is safe, but not without the risks of failure and procedural complications. Failure to successfully cannulate the IJV occurs in the range of 2% to 9%.[10] Failure rates may be greater in patients who have had multiple prior vascular access procedures and in patients with difficult anatomy. Failure to successfully cannulate the IJV on an initial attempt may also increase risk of pneumothorax because of multiple needle passes or the increased difficulty encountered in performing the procedure may increase the subsequent risk of catheter associated bloodstream infection.

The most common complication of IJV cannulation is carotid artery puncture with an incidence ranging from 3% to 10%. Although carotid artery puncture seldom causes a serious adverse event, vascular injuries accounted for the majority of complications leading to claims in the American Society of Anesthesiologists (ASA) Closed Claims Project.[11] In this study, the carotid artery puncture was 9% in land-mark and 1% in ultrasonograpgy technique. Ultrasonography is an easily learned procedure that not only enhances the physical examination but has the distinct advantages of being a portable tool that can provide real-time guidance for IJ CVC placement with significant improvements in first pass success, overall success, and arterial injury.[12,13] GurkanTurker *et al*. found in their study that by using ultrasonography the access time and procedure related complications are reduced.[14] Superiority of the real-time US guidance over the traditional land-mark technique has also been shown by Nadig *et al*.[15] Ultrasound use for insertion of central venous catheters reduces mechanical and infectious complications and increases the success rate and effectiveness while possibly reducing costs and patient discomfort. Using the land-mark technique, we found that the success rate of IJV catheterization was 99% in first attempt and 100% in second attempt, which is consistent with previous reports (ranging from 85% to 99%).[16] Provided that the equipment is available and the training is appropriate, the use of ultrasound is recommended in all patients requiring a central venous access. This technique should be adopted by new clinicians and experienced practitioners as their first line treatment, especially in cases of obesity, edema, coagulation disorders, difficult anatomical land-marks, or positive pressure ventilation in the ICU. Due to the proven benefits of this technique, which ultimately contribute to better patient safety, it will become difficult to justify not using ultrasound when inserting central venous catheters. Ultrasound- guided placements, with a little practice are easier, quicker and safer.[17]

Recently published guidelines have recommended on the basis of level-1 evidence that properly trained clinicians should use real-time ultrasound during IJV cannulation whenever possible to improve cannulation success and reduce the incidence of complications associated with the insertion of large-bore catheters.[18] The National Institute of Clinical Excellence (NICE) issued guidelines recommending that ultrasound guidance be used for all elective and considered for all emergency central venous cannulations in the National Health Service (England and Wales).[19] In the United States, the Agency for Health Care Research and Quality identified use of real-time ultrasound guidance for central venous cannulation as one of the items in its list of best practices to improve patient safety.[20] Clearly there is some aspect of gaining a procedural skill that is numbers based. The Royal College of Radiology recommends 25 line insertions but also acknowledges

that "different trainees will acquire the necessary skills at different rates and the end point of the training program should be judged by an assessment of competencies."[21] With ultrasound, it is possible to identify anatomical variations and confirms the patency of the internal jugular vein. Karakitsos *et al*. compared ultrasound guidance with the land-mark technique in 900 ICU patients. The operators had ten years' experience in inserting vascular catheters without ultrasound and five years' experience with ultrasound guidance. The success rate was 100% with ultrasound and 94% when relying on the traditional land-marks alone. There was a faster mean access time and a lower mean number of attempts with ultrasound compared with the land-mark technique (17 seconds vs. 44 seconds, respectively and 1.1 attempts vs. 2.6 attempts, respectively). With ultrasound, the complication rate was reduced by 57%. The authors observed a significant difference in favor of ultrasound in the incidence of punctures of the carotid artery (1.1% vs. 10.6%), haematoma (0.4% vs. 8.4%), pneumothorax (0% vs. 2.4%) and haemothorax (0% vs. 1.7%).[22] According to Hind *et al*. and Calvert *et al*., there were 86% fewer failures and 41% fewer failures on the first attempt.[23] These studies were used to establish the 2003 National Institute for Clinical Excellence recommendations.[24] In a study evaluating lawsuits, Domino *et al*. concluded that the use of ultrasound could have prevented incidents in 28 patients out of 110 patients involved in a legal action.[25] Another beneficial aspect of using ultrasound is that anatomic knowledge gained by using ultrasound is valuable because it may make one a better operator when ultrasound is not available.

Limitations of this study included inter-operator variability in his expertise and ability to perform the procedures and the number of cases which were fifty in each group. Although the ultrasound method has been favorably compared to the land-mark technique, its widespread use has been hampered by the unavailability of equipment, such as the specially designed ultrasound device, and the lack of trained personnel.

CONCLUSION

Real-time ultrasonography is a valuable technique for cannulation of internal jugular vein and its use facilitates proper catheter placement, reduces the time required to complete the procedure and substantially minimizes potential complications.

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