

Original Article

A comparative study of Internal Jugular Vein Cannulation : Ultrasound Guided Technique versus Conventional Blind technique

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Central line cannulation is usually done in right Internal Jugular Vein (IJV) for long term administration of fluid, antibiotic, hemodialysis, chemotherapy. IJV cannulation is routinely done by Conventional Blind Technique (CT) using landmarks. Nowadays Ultrasound Guided Technique (UT) is used to cannulate IJV. The aim of this study was to compare outcome of the Ultrasound guided technique with conventional technique in terms of success rate, number of attempts for IJV location and cannulation, time required for procedure and complications. This study was conducted on 120 patients who were randomly divided into 2 groups. For both the group of patients seldinger technique was used to cannulate IJV. In Ultrasound guided technique, IJV was cannulated with real time linear transducer probe with high frequency. IJV was cannulated in first attempt in 90% of patients with Ultrasound guided technique and 61.66% of patients with conventional technique ($P=0.03$). Second attempt was required in 10% of patients with Ultrasound guided technique and 30% of patients with conventional technique ($P=0.01$). Third attempt was required in 8.33% of patients with conventional technique while it was nil in Ultrasound guided technique. Mean time for procedure was 7.78+2.75 minutes in Ultrasound guided technique and 19.4+5.68 minutes in conventional technique ($p=0.025$ is significant). In Ultrasound guided technique, rate of complications like, carotid puncture was none, hematoma 8%, difficulty in cannulation 1.66% which are less as compared to conventional technique (8%, 21.66%, 10% respectively). Thus, use of real time Ultrasound for IJV cannulation is beneficial than conventional technique in terms of decreased number of attempts for IJV location and cannulation, less access time and decreased incidence of complications.

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Key words : IJV cannulation, Ultrasound Guided Technique, Conventional Technique.

Central line cannulation is usually done in Internal Jugular Vein (IJV) because of its anatomical position, larger diameter and minimal obstruction in its route to right atrium. IJV cannulation is commonly performed to obtain access to central venous line for long term administration of fluid, antibiotic, total parenteral nutrition, hemodynamic monitoring (CVP-central venous pressure monitoring), hemodialysis, chemotherapy¹. Cannulation of right IJV has been the preferred method for central venous cannulation² because right IJV is in a straight line to right atrium and shorter route, while on the left side the dome of the pleura is higher and chances of damage to thoracic duct. IJV cannulation is done routinely by conventional blind technique using landmarks. Nowadays, Ultrasound Guided Technique is used to cannulate IJV. Ultrasound is a non-invasive, non-ionising form of imaging that is safe for all

age group patients. It has been suggested that Usg Guided Technique has higher success rate, less number of attempts for IJV location and cannulation, less time required for IJV cannulation and less procedure related complications³. Failure to successfully cannulate IJV occurs in the range of 2% to 9% in conventional technique⁴. The aim of this study was to compare outcome of the Ultrasound Guided Technique for IJV cannulation with Conventional Technique in terms of number of attempts for IJV location and cannulation, total access time (time from skin puncture to aspiration of venous blood) and complications related to the procedure.

MATERIAL AND METHOD

This study was conducted in Civil Hospital, Ahmedabad on randomly selected 120 patients who required IJV cannulation. It is a prospective, randomized, interventional, controlled type of study. CTRI registration of the study was not done. All the patients were evaluated before the procedure and written informed consent was taken. Patients of age group 18-75 years, with normal coagulation profile and platelets count >80,000 were included in our study. Patients with abnormal coagulation profile, known

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vascular abnormality were excluded from the study. IJV cannulation was done in various patients undergoing for major prolonged surgery (pheochromocytoma, whipple's surgery, large thyroid mass, neurosurgery), intraoperative CVP monitoring, patients requiring long term antibiotics/fluid, patients requiring TPN (total parenteral nutrition), patients undergoing for hemodialysis, in patient with difficult peripheral venous access. Procedure was carried out in operation theatre in full aseptic precaution with necessary monitors applied and equipments available. No intravenous medication was given before or during procedure. Patients were randomly divided into 2 groups of 60 each, group conventional technique (CT) and Ultrasound Guided Technique (UT) using computer generated random list. In conventional technique group, IJV was cannulated by landmark guided seldinger technique. In Ultrasound Guided Technique group, IJV cannulation was done by using Ultrasound imaging system (SONOSITE) with a 7.5-MHz transducer probe connected to a two-dimensional ultrasound device. The patient was kept in supine position with head turned to opposite side for complete exposure of procedure side and a shoulder pack was placed to extend the neck (except in patient of cervical spine injury in whom the neck was kept in supine position only). After applying monitors (SPO₂ and ECG), painting and drapping was done and Inj. Lignocaine 2% was injected on the site of needle entry.

In conventional technique surface landmarks are apex of the triangle made by 2 heads (sternal and clavicular) of sternocleidomastoid muscle and medial third of clavicle just lateral to carotid pulsations. 20 Gauge needle was advanced at 45 degree angle to skin directed towards ipsilateral nipple. After aspiration of free flow of venous blood in saline filled syringe, a guide wire was passed through the needle into IJV and needle was removed. Finally 18 G radio-opaque catheter was cannulated over guide wire into IJV and guide wire was removed. Catheter was secured with proper stitches.

In Ultrasound Guided Technique, we used real time (Dynamic) method which allows needle observation as the needle approaches the target vessel. The linear transducer probe with high frequency was used, since the vascular structures are typically shallow. Transducer probe was kept in sterile plastic bag with ultrasonic gel applied on it. We kept the probe perpendicular to the floor which is parallel and approximately 1.5 cm above the clavicle (Outplane technique), so only tip of advancing needle can be seen on monitor. Position of IJV in relation to carotid artery was accessed first and 2% lignocaine was injected with 24 g hypodermic needle 0.5 cm above the site of probe. The wheel in subcutaneous tissue was visualized on monitor as enlarging hypoechoic area. 20 G needle was advanced through this skin wheel towards IJV keeping vein in centre

of the monitor. Tip of needle (visualized as hyperechoic dot) was advanced towards anterior wall of IJV. The vein was pierced by a short stabbing motion of needle which leads to puncture in anterior wall of IJV without causing double wall puncture. When the tip of the needle was located in vein, confirmation was done by aspiration of venous blood. We also confirmed IJV location by keeping the probe in plane of IJV so we were able to visualize anterior and posterior walls of vein with tip of needle inside. Then insertion of 18 G catheter was done by seldinger's technique same as mentioned in conventional technique. Successful placement of catheter was confirmed by Chest x-ray and post-procedure arterial blood gas analysis.

In our study, data recorded were patients' demographic data, number of attempts for IJV location, total access time (time from skin puncture to aspiration of venous blood) and complications related to procedure (such as hematoma, arterial puncture, difficulty in IJV cannulation, hemothorax, pneumothorax, brachial plexus irritation, failure of procedure). Primary outcome of this study is successful cannulation in first attempt and secondary outcome is duration of procedure and complications related to procedure.

We have calculated sample size by using power analysis and sample size version 8(2008) software. According to this, sample size was calculated to be 58 in each group at 80% power of study and 0.05 level of significance (a) using two-tailed chi-square test. It was done to detect absolute difference of 20% for successful cannulation of IJV in first attempt by Ultrasound Guided Technique and conventional technique. To be on safer side, we decided to keep 60 patients in each group.

Statistical package for social science version 23 (23, IBM, Chicago, USA) was used for analysing the data. All data are presented as mean and % of patients. A chi-square test was used to compare categorical variables and a student's t-test was used to compare independent means. P value <0.05 was considered significant.

OBSERVATION

Our study was a single blinded observational type of study carried out on 120 patients who required IJV cannulation. Our 2 study groups were similar in regards to patients' demographic data (age, sex, weight) and site of IJV insertion (Tables 1 & 2).

IJV was cannulated in first attempt in 90% of patients with Ultrasound Guided Technique and 61.66% of patients with conventional technique (p=0.03). Second attempt was required in 10% of patients with Ultrasound Guided Technique and 30% of patients with conventional technique (p=0.01). Third attempt was required in 8.33% of patients with conventional technique while it was nil in Ultrasound Guided Technique (Table 3).

Table 1 — Demographic Data		
Group	Usg guided technique (n=60)	Conventional technique (n=60)
Age (Years)	40.31+14.84	43.95+17.97
Sex (M/F)	36/24	23/37
Site of IJV (Right/Left)	59/1	57/3

Table 2 — Number of attempts for successful vein localization			
No of patients cannulated in	UTN (%)	CTN (%)	P Value
First Attempt	54(90%)	38(61.66%)	0.03
Second Attempt	6(10%)	18(30%)	0.01
Third Attempt	0(0)	5(8.33%)	

Table 3 — Total Time Required For IJV Cannulation			
Mean time for IJV Cannulation (minutes)	Usg guided technique	Conventional technique	P value
	7.78+2.75	19.4+5.68	0.025

Table 4 — Showing Complications		
Complications	Usg guided technique	Conventional technique
Carotid puncture	0(0)	5(8%)
Hematoma	5(8%)	13(21.66%)
Difficulty in cannulation	1(1.66%)	6(10%)



Fig 3

Fig 4

Total access time is considered from skin puncture to aspiration of venous blood. Mean time for procedure was 7.78+2.75 minutes in Usg Guided Technique and 19.4+5.68 minutes in Conventional Technique having P=0.025 which is significant (Table 4).

In Ultrasound Guided Technique there were no cases of carotid artery puncture while it occurred in 8% of patients in Conventional Technique. Hematoma occurred in only 8% of patients with Ultrasound Guided Technique as compared to 21.6% of patients in Conventional Technique. Difficulty in threading guidewire after successful IJV cannulation occurred only in 1.6% of patients with Usg guided technique as compared to 10% of patients in Conventional Technique. There were no cases of haemothorax, pneumothorax, and brachial plexus injury in any of techniques during the study.

Ultrasound Guided Images — Outplane technique :

The probe is kept perpendicular to the floor which is parallel and approximately 1.5 cm above the clavicle. In this technique tip of advancing needle and adjacent vascular structure is seen on monitor (Figs 1 & 2).

Inplane technique :

Probe is kept perpendicular to clavicle and in line with anatomical location of IJV. Whole course of advancing needle towards vein can be seen on monitor (Figs 3 & 4).



Fig 1



Fig 2

DISCUSSION

As per our study, in Ultrasound Guided IJV cannulation procedure time (7.78+2.75 minutes in UT) is less compared to Conventional Technique (19.4+5.68 minutes in CT), procedure related complications are negligible with use of Ultrasound, number of attempts for IJV cannulation are less with Ultrasound Guided Technique. (IJV was cannulated in first attempt in 90% of patients with Ultrasound Guided Technique and 61.66% of patients with Conventional Technique)

Considerable amount of time and efforts are spent on insertion of central venous catheter for various purposes, but IJV cannulation is not without risk and may lead to adverse effects that are both hazardous to patients and expensive to treat. Nowadays Ultrasonography is most widely used imaging technique in medical practice. USG is portable, nonradiating, and inexpensive as compared to other imaging modalities such as MRI, CT scan. In modern Ultrasound, a small pulse of echo is transmitted from transducer to body which penetrates body tissue along the path of transmission. Some waves are reflected back to transducer and some continue to penetrate deeper depending upon different acoustic impedances of tissues. The wavelength and frequency of Ultrasound are inversely related. Superficial structures are visualized with high frequency waves and low frequency waves are used to visualize deeper structures⁵. Ultrasonography has specific advantages in cannulating a vessel over conventional blind technique like visualization of a vascular structure, optimal needle placement, avoids puncture of posterior wall of IJV, accurate placement of catheter inside IJV, confirmation of guidewire inside IJV, less number of attempts and lower rate of complications.

As the IJV is a superficial vascular structure, the linear transducer probe with high frequency was used. Most of the patients in our study showed lateral and anterolateral lying IJV relative to carotid artery. We measured depth of IJV from skin which was approximately 0.8 ± 0.4 cm (Fig 5).

On radiological visualization artery is circular in shape, pulsatile, thick walled and non-compressible when pressure is given by probe. While vein is elliptical in shape, non-pulsatile, thin walled and compressible by pressure.

Ultrasonography is useful for central line cannulation as either dynamic technique or static technique. In dynamic technique (also known as real time), the whole procedure is accompanied by the use of USG⁶. While in static technique, USG is used pre-procedure for marking the puncture site, visualization of anatomy and post-procedure to detect possible complications. We used dynamic approach for our study as it allows real-time visualization of the needle tip placement and has been shown to be superior to the static approach in most situations. There are 3 different approaches for Ultrasound Guided Technique for IJV cannulation like outplane, inplane and oblique^{7,8}. Outplane (transverse axis) approach has advantage of visualization of adjacent structures and short learning curve but disadvantage of higher risk of injury to the posterior wall of the vessel. Inplane (longitudinal axis) approach has advantage of visualization of vessel, guide wire, catheter during whole procedure but disadvantage is inability to visualize adjacent structures. Third approach is, the oblique, is an intermediate to the previous two⁹. In our study, we kept the probe perpendicular to the floor and parallel to the clavicle (Outplane technique), so only tip of advancing needle and adjacent structures can be seen on monitor. Later on, after aspiration of venous blood, we confirmed IJV location by keeping the probe perpendicular to clavicle (inplane of IJV), so we were able to visualize anterior and posterior walls of vein with tip of needle inside.

All datas are normally distributed in both the Ultrasound Guided Technique and Conventional Technique groups in terms of age, gender (m/f) and site of IJV insertion (rt/lr).

A Study on 200 patients done by Azmat Riaz et al described that vein was localised on 1st attempt in 99% of ultrasound-group patients and in 89% of land-mark-group patients. 2nd attempt was required in 1% of patients of ultrasound-group and 7% of patients of land-mark-group¹⁰. In our study, IJV was cannulated in first attempt in 90% of patients with Ultrasound Guided Technique and 61.66% of patients with Conventional Technique ($P=0.03$). Second attempt was required in 10% of patients with

Ultrasound Guided Technique and 30% of patients with Conventional Technique ($P=0.01$). Third attempt was required in 8.33% of patients with Conventional Technique while it was nil in Ultrasound Guided Technique (Table 2). Thus study results are comparable with our study.



Fig 5

Carotid arterial puncture is the most common and frequent complication of IJV cannulation due to its anatomical proximity of 2 vessels. According to our study, In Ultrasound Guided Technique there were no cases of carotid artery puncture while it occurred in 8% of patients with Conventional Technique. Hematoma occurred in only 8% of patients with Ultrasound Guided Technique as compared to 21.6% of patients with Conventional Technique (Table 4). As per study by Darko Sazdov, Marija Srceva *et al* carotid artery puncture occurred in 1% of patients of ultrasound group, while in 8% of patients in land-mark technique ($p=0.0007$). Hematoma occurred in 4% of patients with Ultrasound as compared to 10% of patients with landmark technique ($p=0.01$)¹⁰. This data are comparable with our study results. Similar results were found by Gurkan Turker *et al* which shows carotid puncture and hematoma are less with Usg (0.5% and 1% respectively) as compared to conventional technique (4.73% and 3.68% respectively)¹¹. The rate of complications such as accidental puncture of the carotid artery, hemothorax, pneumothorax, and hematoma, as well as the total procedure duration and the occurrence of bloodstream infection associated with catheter, was significantly lower in the group that underwent Ultrasound Guided catheterization¹². Superiority of Ultrasound Guided Technique over Conventional Technique is seen in patients with obesity, oedema, coagulation disorders, difficult anatomical landmarks, chest deformity, previous surgery, burns, cervical spine injury where neck movements are restricted, hypovolemic patients. Due to proven benefits of Ultrasound Guided IJV cannulation, it will be difficult to justify not using Usg for this procedure. The National Institute for Clinical Excellence (NHS 2002) guidelines issued in 2002 recommend the use of ultrasound for IJV cannulation in both adults and children in most circumstances in both elective and emergency situations¹³. In February 2012, International Committee of Ultrasound

Vascular Access published its recommendations and concluded that, the vascular catheterization must be guided by Ultrasound due to its efficacy and safety provided by the procedure. The National Institute of Clinical Excellence (NICE) issued guidelines recommending that Ultrasound Guidance be used for all elective and emergency central venous cannulations in the National Health Service (England and Wales)¹⁴.

However there are limiting factors like unavailability of Ultrasound machine due to high cost and need for an experienced operator who has an understanding of probe orientation, image display, the physics of ultrasound, and mechanisms of image generation and artefacts. In our study, Out of total 120 patients, in 2 patients of burns contracture involving neck and in 2 patients with cervical spine injury in whom neck movements were restricted, Ultrasound Guided Technique was used because conventional technique guided IJV cannulation was not possible at all. There were 3 cases in which IJV cannulation was failed by blind technique and later on succeeded by Ultrasound Guided Technique. So success rate of IJV cannulation was 100% with Ultrasound Guided Technique and 95% with conventional technique. Similar results were observed in study done by Shah H, Bhavsar M¹⁵. Thus use of USG for IJV cannulation reduces mechanical and infectious complications¹⁶, reduces chances of thrombosis, increases success rate and decreases patient discomfort.

CONCLUSION

Use of real time Ultrasound for Internal Jugular Vein cannulation is beneficial than conventional landmark guided technique in terms of decreased number of attempts for IJV location and cannulation, decreased access time, decreased incidence of complications, increased success rate and substantially decreased patient discomfort. Patient discomfort was not measured using any scoring system, but patients in whom IJV cannulation was done with Ultrasound were more comfortable in terms of short procedure time, less number of attempts and less complications.

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