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Real-time Ultrasound-guided Catheterisation of the Internal Jugular Vein: A Prospective Comparison with the Landmark Technique

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Abstract

Central venous access has become a mandatory part for clinical management of critically ill patients, both in acute care setting and chronic long term care. However, anatomical landmark guided technique for IJV cannualation is not devoid of complication like carotid arterial puncture and pneumothorax. In this prospective, randomized, controlled, clinical trial, we compared and assess the anatomical landmark guided technique for IJV cannulation with USG guided technique in terms of success rate, no. of attempts and complications. Sixty four patients of either sex, between age group of 18 –70 years requiring either elective or emergency CVC placement, were randomly divided to 2 groups, Group USG: USG guided technique and Group ALG: Conventional or anatomical landmark guided technique. Venous access time and catheterization time both were found to be statistically significantly less in USG group compared to ALG group ($p<0.0001$). Successful cannulation in 1st attempt could be done in more no. of patients in USG group (26 patients) compared to ALG group (6 patients) ($p<0.00001$). Success Rate was 87.5% in Group ALG while it was 100% in Group USG. Which was statistically highly significant ($p<0.05$). Overall Complications rate was 25% versus 3.125% in Group ALG and group USG respectively which was statistically significant.($p<0.05$).Ultrasound guided central venous catheter placement is easy, safer and prudent approach than anatomical landmark guided technique hence should be encouraged to improve patient's safety and quality care.

Keywords: Internal Jugular Vein Cannulation; Ultrasonography; Anatomical Landmark Guided Technique.

Introduction

Central venous catheterization has become an integral part of management in emergency as well as in critical care medicine [9], required for the administration of hyperosmotic or vasoactive compounds, cytotoxic drugs, parenteral nutrition, and rapid infusion of large volume of fluid or for continuous or intermittent monitoring of biochemical and physical parameters [9]. Hermosura et al. described right internal jugular cannulation in 1966 and since then it has become one of the most popular route for central venous cannulation [5]. IJV has gained popularity among different central cannulation route due to its consistent anatomical position, large diameter and less chances of catheter misplacement and obstruction [14].

However, placing central venous line entails risks and rate of major and minor mechanical complications can be as high as 10% [9]. Failure to cannulate the vessels may occur in >19% of patients [11]. Complications like puncture of the carotid artery, neck or mediastinal hematoma, pneumothorax, injury or irritation of brachial plexus, phrenic nerve or recurrent laryngeal nerve and stellate ganglion can be encountered [6]. Standard technique for placing central venous catheter is by using anatomical landmarks but patients with coagulopathies, vascular and skeletal deformities, obesity, edema, h/o previous catheterisation or

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unusual small habitus, neck burn contracture make cannulation more difficult [11,12].

In 1978, Ulman and stoelting described the first use of ultrasonography for accessing central veins. They reported this new technique would increase the success rate of IJV catheterization and decreases accidental puncture of carotid artery compared with the traditional technique using only anatomical landmarks [8]. In 1986, Yonei et al reported the use of real time ultrasonographic guidance for IJV cannulation [8].

The agency for Health Care Research and Quality in USA and National Institute of Clinical Excellence in United Kingdom have recommended the use of USG guidance for CVC placement to improve success rate, reducing no. of attempts and decreasing complications and hence patient care.[8] Advances in speciality care and availability of portable ultrasonography (USG) units in hospitals have made the use of USG for bedside procedures possible [9].

In this study, we compared and assess the anatomical landmark guided technique for IJV cannulation with USG guided technique in terms of success rate, no. of attempts and complications.

Materials and Method

After approval from institutional ethical committee, written informed consent was taken from all patients. Sixty four patients of either sex, age group of 18 – 70 years requiring either elective or emergency CVC placement were included in this study. Patients were randomly divided into 2 groups: (32 patients in each group)

Group USG: USG guided technique and Group ALG: Conventional or anatomical landmark guided technique.

The Patients were subjected to detailed history, thorough clinical examination and laboratory investigations including coagulation profile, Chest X-ray and ECG.

Exclusion Criteria

- Non-cooperative patient
- Skin infection over puncture side
- Children (<18yrs of age)
- Anatomical deformity, eg. Neck surgery, malignancy
- Cellulitis, severe dermatitis, Burns on site of insertion
- Vasculitis
- Bleeding disorders
- Cardiac arrhythmia
- Pneumothorax / hemothorax
- compromised unilateral lung

In this study, CVC placement was done by Seldinger technique in both USG and anatomical landmark group. A technique introduced in the 1953 and called the *Seldinger technique* after its founder-Dr. Sven-Ivar Seldinger.

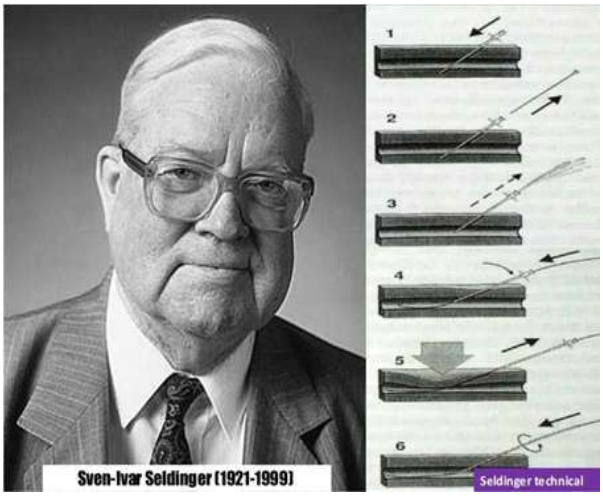

Fig. 1: Steps of seldinger's technique

Peripheral venous cannula was assured in all patients and Standard monitoring (pulse, BP, SpO_2 and ECG) were applied. Right sided internal jugular vein (IJV) was first planned for cannulation in this study.

Position of the Patient

The patient was placed in supine position with slightly head down around 10-30° (Trendelenburg position) and neck rotation (30°) contra-lateral side. Wedge was placed between shoulder blades. Part preparation & draping was done, taking all aseptic and antiseptic precautions.

A portable ultrasound "Sonosite Micromaxx" machine with 7.5 MHz Linear array (vascular) probe was used in this group. Probe was cleaned with antiseptic solutions, sterile jelly was applied and covered with sterile sheath. Probe was placed perpendicular to the area at apex of the triangle formed by two heads of sternocleidomastoid (SCM) muscle and clavicle. In the longitudinal plane, the

probe was oriented with the marker towards the patient's head and in the transverse plane, the marker facing towards the patient's right side. Internal carotid artery (ICA) was seen as a circular pulsatile structure while IJV as an oval non-pulsatile structure. On applying downward pressure with probe, IJV get compressed whereas ICA remained as such. Once vein was identified, probe was positioned so that vein was visualized in centre of the screen. 2% inj. Lignocaine hydrochloride was injected overlying access site for local anesthesia and skin puncture utilizing sterile needle was commenced. Needle was kept at the same distance from transducer as the distance between transducer and vessel and making angle 45 degree with transducer in case of short axis view.

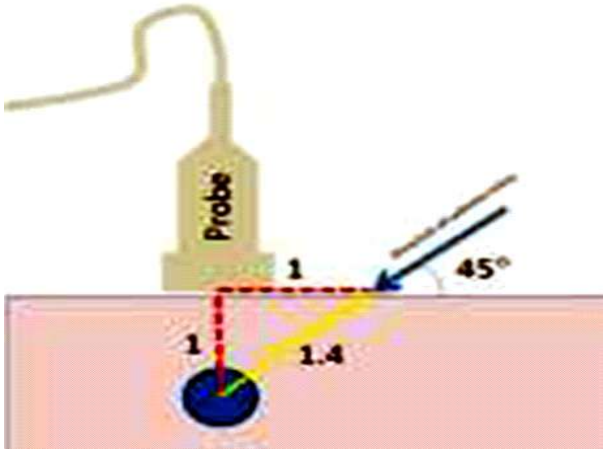

Fig. 2: Needle direction in short axis view

For long axis view needle was kept just outside to the edges of probe and 30 degree angle to the skin surface. Introducer needle could be seen on monitor either puncturing the vein or compressing the vessel wall, by identifying needle tip echo. Needle was further advanced till visualization of entrance of the needle into vessel lumen, thereby avoiding a double-wall puncture. After successful aspiration of blood, a guide wire was inserted through it by visualizing ultrasound image in longitudinal plane. Then after CVC placement was done using seldinger technique.

Fig. 3: Placement of probe parallel and perpendicular to IJV

Anatomical Landmark Guided Technique

Apex of the triangle formed by two SCM was palpated for carotid pulsations. With fingers of the left hand, carotid artery was pressed slightly medially and introducer needle inserted lateral to pulsation point, directing toward the ipsilateral nipple at an angle of 20-30 degree with the skin. After successful aspiration of blood, a guide wire was inserted through it and introducer needle was withdrawn. Rest of the procedure was similar to that in group USG. (Seldinger technique) Vital parameters were checked during and after procedure.

Statistical analysis was done using SPSS software. P value<0.05 was considered statistically significant and p<0.01 was highly significant.

Results

Both groups were comparable with respect to age, sex, body weight and indication for IJV cannulation. (p>0.05)

The mean duration of Venous Access Time (1.28±1.03 minutes) in Group USG was significantly less compared to (5.78±2.75 minutes) Group ALG (p < 0.0001).

The mean duration of Catheterisation time in Group ALG was 8.3±2.17 minutes compared to Group USG (3±1.25 minutes), which was found to be statistically extremely significant (p < 0.0001). (Table 1) 6 no. of patients (18.75%) in Group ALG while 26 patients (81.25%) in Group USG out of 32 patients could be cannulated successfully in 1st attempt. (p<0.00001) So, successful cannulation in 1st attempt could be done in more no. of patients in USG group compared to ALG group.

Success Rate was 87.5% (28 patients out of 32 patients) in Group ALG while it was 100% (32 patients out of 32 patients) in Group USG. This result was statistically highly significant (p<0.05).

Overall Complications rate was 25% versus 3.125% in Group ALG and group USG respectively which was statistically significantly less (p<0.05)(Table 2).

Discussion

Central venous catheterization has become an integral part of management in emergency as well as in critical care medicine [9]. Even with

Table 1: IJV catheterization characteristics in group ALG and USG

Parameters	Group ALG(n=32 patients)	Group USG (n=32 patients)	P value
Mean venous access time(minutes)	5.78±2.76	1.28±1.03	P<0.0001
Mean catheterization time(minutes)	8.3±2.17	3.00±1.25	P<0.0001

Table 2: Comparison of complications

Complications	Group ALG		Group USG		P value
	n=32 patients	Per. (%)	n=32 patients	Per. (%)	
Carotid artery puncture	3	9.375	1	3.125	P<0.002
Pneumothorax	0	0	0	0	
Hemothorax	1	3.125	0	0	
Others	4	12.5	0	0	
Other parameters					
Change of puncture site	3	9.375	0	0	P<0.076
Failure rate	4	12.5	0	0	P<0.04

experienced hands, complications rates of 12.3% have been reported for CVC using the anatomical landmark guidance [7]. Considering increased use of CVC efforts should be made to minimize & prevent the occurrence of complications and thereby improving patient safety and quality care.

Ultrasound technology has become essential tool for everyday practice of anesthesiology i.e. the placement of central, arterial and peripheral lines as well as peripheral nerve blocks [8]. Modern Ultrasound machine are compact, portable & handy with good resolution, real time guidance & safety to patient and operator [7]. (No radiation) Ultrasound has been first described in 1984 by Legler and Nugent as either a prelocating device or a real-time guidance device for central venous cannulation. With availability of portable USG machine, USG guided interventions can save the time & increases accuracy, efficacy & safety [7]. Thus USG is a valuable tool to reduce the medical errors and to improve the medical care [9]. "The Stanford evidence based practice centre" has recommended ultrasound guidance in central venous catheter insertion as one of the 11- point recommendations in "A critical analysis of patient's safety practices" in 2001 [7].

"The agency for healthcare quality and research" (AHRQ), in its 2001 report on reducing medical errors in the United States, placed ultrasound guidance for CVC placement in the list of ways to reduce medical error [3].

In 2011, the CDC (Centre for Disease Control and Prevention) recommended use of ultrasound guidance to place central venous catheter to reduce no. of attempts and mechanical complications [8].

Based on meta-analysis in 2002, "National Institute for clinical excellence" in UK has recommended that the use of 2 D ultrasound guidance should be considered in the most clinical situations where a central venous line is necessary electively or in an emergency [7].

In this study, mean venous access time and mean catheterization time, both were shorter in group USG compared to group ALG and statistically extremely significant (p<0.0001).

Bikas R Ray et al. in 2013 [5] compared both ultrasound guided technique: prelocation of the IJV or real time image with anatomical landmark guided technique. It was found that both the median venous access time (9.5sec, 11sec) and the median catheterization time (167.5sec, 165sec) were shorter in ultrasound groups than in anatomical landmark technique. Difference was statistically significant. ($P = 0.024$). Findings of this study and Ankit agrawal et al. [4] are accordance with our study.

In our study the mean no. of attempts for successful cannulation was more in group ALG (2.1±0.72) than the group USG (1.18±0.49), which was statistically extremely significant (p<0.0001).

The average number of needle punctures and the percent of successful cannulations on the first attempt are important factors in central venous cathterisation, since these parameters are strongly associated with the rates of failure and complications [10].

Ultrasound helps to locate IJV, carotid artery and other important surrounding structure before cannulation. So, ultrasound guided prelocation and real-time ultrasound imaging of the needle during cannulation increases the incidence of IJV cannulation in 1st attempt [8].

Results of Adam H. miller et al. 2000 [13], Dr. Sidhharth kumar et al. 2012 [7] and Hadim Akoglu et al. 2012 [10] were consistent with present study.

In present study, we needed more than 3 attempts for IJVcannulation in 4 patients in group ALG with failure of 12.5% and success rate of 87.5%. Success rate was high 100% (81.25%-first attempt, 18.75%-second attempt) in group USG and 3rd attempt was not required. Overall complications rate was 25% in group ALG and 3.13% in group USG. Denys and Reddy in 1993 [6] and Karakitsos et al in 2006 [11] observed similar results in their study. Susan T. Verghese in 1999 [16] observed significantly less carotid artery puncture even in infants with USG guided technique. Mechanical complicatios may lead to life threatening outcomes like cardiac arrhythmia, tamponade and migration of cathter. Under real time USG guidance, location of CVC tip can be confirmed and we can assess immediately for any sign of abnormality for prompt and appropriate management. Thus, reduces complication rate.

Conclusion

From present study we concluded that:

- Ultrasound guided technique for placement of CVC is superior to ALG technique as far as time required and no. of attempts required for insertion of cannula.
- Real time ultrasound guidance decreases incidence of carotid artery puncture and overall complications during CVC placement.

This study evaluated a change in practice of CVC placement. USG guided CVC placement is easy, safe, accurate and prudent approach than ALG technique. So it should be encouraged for all CVC placement and thereby improving patient's safety and quality care. But major impediments to widespread implementation are the purchase cost of the ultrasound machine and training require for operators to get familiar with the technique.

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