MAK HILL Publications Research Journal of Medical Sciences

Research Article
doi: 10.36478/makrjms.2024.10.66.72

A Comparative Study Between Real Time Ultrasound Guided Catheterisation of the Internal Jugular Vein with External Landmark Technique in Patients Undergoing Cardiac Surgery

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Key Words
Ultrasound guided technique success rate, number of attempts, IJV catheterization, landmark technique

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Received: 25 June 2024
Accepted: 15 July 2024
Published: 20 July 2024

Citation: Yuvaraj Shashidhar, Sainath, Shivanand and R.M. Akshay, 2024. A Comparative Study Between Real time Ultrasound Guided Catheterisation of the Internal Jugular Vein with External Landmark Technique in Patients Undergoing Cardiac Surgery. Res. J. Med. Sci., 18: 66-72, doi: 10.36478/makrjms. 2024.10.66.72

ABSTRACT
Catheterization of central veins (CVC) is one of the most commonly performed invasive procedure amongst patients undergoing cardiovascular surgery. These catheters plays an important role in pre-operative, intraoperative as well as post-operative phase. To compare ultrasound guided versus external landmark technique for internal jugular vein access. The present study was conducted in Department of Anesthesiology, Gandhi Medical College and associated Hamidia Hospital Bhopal on a total of 60 patients scheduled for elective or emergency cardiac surgery. All the patients were randomly divided into two groups with 30 patients in each group. Group 1-the landmark guided technique group (LMG). Group 2-the ultrasound guided group (USG). Mean age of patients of landmark guided technique group (LMG) was 45.83±11.48 years whereas mean age of patients of ultrasound guided group (USG) was 43.43±13.38 years. Majority of patients in both the groups were males. Mean weight and neck circumference were comparable between two groups ($p>0.05$). Most common site for IJV cannulation was right internal jugular vein both the groups. Mean access time was significantly lower in USG group (2.36±1.1 minute) as compared to LMG group (5.12±1.6 minute) ($p<0.01$). Mean number of attempts were documented to be significantly higher in LMG group (1.38±0.6) as compared to single attempt in USG group ($p<0.01$). The study documented no significant difference in complication rates between two groups ($p>0.05$). Ultrasound guided technique significantly improve the success rate and decrease the number of attempts required for IJV catheterization. USG guided technique was better in terms of number of attempts, success rate and mean access time as compared to landmark technique.

INTRODUCTION

Central venous catheters are helpful in monitoring of hemodynamic parameters, giving treatment and blood transfusion, intravenous fluid infusions, obtaining samples for investigations, giving parenteral nutrition, hemodialysis and hyper alimentation[1,2]. Apart from this, CVC is also helpful in monitoring intracardiac pressures during anesthetic procedures in patients with ventricular dysfunction[3,4].

Central venous catheterization can be performed from various routes such as internal jugular vein catheterization, subclavian vein, femoral veins or peripheral veins, the actual site of catheterization is chosen based upon indication, individual institutional and operator experiences[2,5]. Internal jugular vein catheterization is the most preferred site for cardiac surgeries as it is associated with low rate of major complications associated with other sites[1,6]. As the right Internal jugular vein enters directly into right ventricle, catheterization of right internal jugular vein reflect pressure in the right atrium and most accurately reflects alteration in volume or compliance of right atrium or ventricle, tricuspid or pulmonary valvular dysfunction and the effects of increased right ventricular after-load. Thus, amongst patients undergoing cardiac surgery, internal jugular vein catheterization is helpful in monitoring major alteration of pre-load, after-load or contractility during the perioperative period.

The filling pressure measurements obtained by central venous pressure monitoring helps in differentiation between hypovolemia and myocardial depression[7,8]. Measurement of central venous pressure indirectly reflect left ventricular functions and correlates with changes in pulmonary as well as left ventricular end diastolic pressure[9].

Central venous catheterization is usually performed using a landmark technique. Though CVC using landmark technique is a standardized procedure but it may be associated with complications even in experienced hands. Complications may range from mild local hematoma to severe complications which include chylothorax, hemothorax, pneumothorax, or mediastinitis[1]. In some cases, CVC may be associated with catheter malpositions and even death during the procedure.

However rate of major as well as minor complications have been documented to be as high as 10%[6]. The risk of complications is higher in infants, obese individuals and patients with short neck, urgency of placement, presence of atypical vascular anatomy, patients with impaired coagulation status and history of previous catheterizations[10].

Real time ultrasonography has been recommended to view the in vivo vascular anatomy of the neck and thus in estimating the size of IJV and its anatomical relations. This method was first described Legler[11,12] to ensure the visualization of anatomic variations before interventions, independent of location and continuous observation of the needle during cannulation. CVC when conducted under the guidance of USG is associated with lower rates of complications[13].

Thus it has been suggested that in ideal situations, ultrasound guided catheterization might improve the success rate, reduce the number of attempts of catheterization and decrease the rates of complications[11,12]. Although the ultrasound guided catheterization have been associated with significantly lower complication rates, its widespread use is affected by unavailability of equipment or the trained personnel and high cost[13].

With the above background, the present study was conducted at tertiary care centre to assess the ease, safety and success rate of IJV catheterization using a standard approach based on anatomical landmark and compare it with that of catheterization conducted using ultrasound-guided approach.

MATERIALS AND METHODS

This Comparative and Prospective hospital based study was conducted in Department of Anesthesiology, Gandhi Medical College and associated Hamidia Hospital, Bhopal among all the patients belonging to age range of 18-60 years scheduled for elective or emergency cardiac surgery at the study area during the study period amongst adults undergoing cardiac surgery during the study period of 2 years i.e. from 1st July 2018-30th June 2020.

Inclusion Criteria:

- Patient aged above 18 yrs of either sex.
- Must give their informed written consent.
- Patients requiring central venous catheterization for.
- Heamodynamic monitoring.
- Long term administration of fluids/drugs/total parental nutrition.

Exclusion Criteria:

- Conditions of severe bleeding tendency and coagulopathy states (platelets <50,000, INR >2).
- Infections, burns or presence of cancerous lymph nodes in the area.
- Obstruction of the superior and inferior vena cava.
- Severe respiratory distress, tachypnea and labored respirations.

Methodology: After obtaining ethical clearance from institute's ethical committee, all the 60 patients fulfilling inclusion criteria and giving consent for the study were enrolled. Detailed data pertaining to their sociodemographic variables such as age, gender,

socioeconomic status was obtained from all the study participants and entered in pretested semistructured questionnaire. Sixty Patients were given serial number and were randomly divided into two groups with 30 patients in each group

Group 1: The landmark guided technique group (LMG) and.

Group 2: The ultrasound guided group (USG).

Detailed history was obtained from all the study participants including history of previous surgery, long term illness, bleeding tendency and history of previous central venous cannulation. Further all the patients were subjected to detailed physical examination including presence of uncorrected bleeding diathesis, skin infection over puncture site, pneumothorax or hemothorax or the presence of only one functional lung, skeletal deformity or scarring. Circumference of the neck at the thyroid prominence and the distance from the suprasternal notch to the right mastoid process was measured. Participants were subjected to all necessary routine investigations.

PRE Procedure Preparation:

- The procedure was explained to patients.
- All the patients were reassured.
- Preanaesthetic check up and medical fitness was obtained.

Position of the Patient: The patient was placed in supine position with 15 degrees of Trendelenburg position and the head turned slightly, 20-30 degrees, to the opposite side to expose the neck better and to keep the chin away from the procedure. Flexion and extension of the neck were avoided.

Supplemental oxygen was provided throughout the procedure. ECG, non invasive blood pressure (NIBP) and oxygen saturation were monitored continuously throughout the procedure. Bilateral breath sounds were confirmed by auscultation and documented before the procedure. The anatomical land marks were identified. The neck was surgically prepared using antiseptic solution and draped. The operator wore gown, cap, mask and sterile gloves. All patients were given 2% lidocaine as local anaesthetic.

Landmark Technique: After preparing parts, 2% lidocaine was injected at the site of CVC in the apex SCM triangle of the neck. The finder needle of 23G size was attached to 5 cc syringe containing heparinised saline, was advanced through the skin at 45 degree angle in the direction of ipsilateral nipple. When venous blood was aspirated the finder needle was used to guide 18G needle connected to 5 cc syringe as a seeker needle. The Seldinger technique with J-tip guide wire was employed for central venous cannulation.

Ultrasound-Guided Technique: Standardized 2-D ultrasound unit with 3.5 MHz transducer was used. Asepetic precautions were taken. The transducer contact surface was covered with 5% povidone-iodine solution and a sterile transparent occlusive material, tegaderm. Sterile 5% Povidone-Iodine solution was used as the ultrasound conductive medium between the transducer and the patient's skin.

Ultrasound scanning was done with the help of sonologist. The transducer was placed parallel and superior to the clavicle, over the groove between the sternal and clavicular heads of the sternocleidomastiod muscle. Both internal jugular vein and carotid artery were visualized. The finder needle attached to 5 cc syringe containing heparinised saline was advanced through the skin, internal jugular vein was located and the needle was visible on the screen. The finder needle was used as a guide to advance 5 cc syringes with 18G needle.The Seldinger technique with J-tip guide wire was employed for central venous cannulation. All the cases were subjected to chest X-ray posterio-anterior view for confirmation of catheter position.

Statistical Analysis: Data was compiled using MsExcel and analyzed using IBM SPSS software version 20. Data was grouped and expressed as frequency and proportions whereas numerical data was represented as mean and standard deviation. Chi square test was applied to compare the difference in proportions between two groups whereas mean difference was calculated using independent sample t test. $P<0.05$ was considered significant.

RESULTS AND DISCUSSIONS

The two groups were compared with respect to ease of central line, access time, attempts and complications. Mean age of patients landmark guided technique group (LMG) was 45.83±11.48 years whereas mean age of patients of ultrasound guided group (USG) was 43.43±13.38 years. Majority of patients of LMG group (36.7%) belonged to more than 50 years of age group and maximum patients of USG group (46.7%) belonged to 41-50 years of age. The observed difference in age between two groups of patients was statistically insignificant and thus two groups were comparable with respect to age ($p>0.05$). In present study, about 60% and 73.3% participants in LMG and USG group respectively were males. Two groups were comparable with respect to gender ($p>0.05$).

Table 1: Comparison of weight and Neck Circumference Between two Groups of Patients.

Anthropometry		LMG (n=30)	USG (n=30)	T value	p-value
Weight	Mean	63.6	65.3	0.51	0.613
	SD	8.5	16.2		
Neck circumference	Mean	35.7	36.2	0.48	0.631
	SD	4.1	3.9		

Mean weight of patients of LMG group was 63.6±8.5 kg, whereas mean weight of patients of USG group was 65.3±16.2 kg. Similarly, mean neck circumference in patients of LMG and USG group was 35.7±4.1 and 36.2±3.9 kg respectively. The observed difference between weight and neck circumference of patients between two groups was statistically insignificant (p>0.05).

Table 2: Distribution According to Site of Cannulation

Site	LMG (n=30)	USG (n=30)
Left Internal jugular vein	1 (3.3)	1 (3.3)
Right Internal jugular vein	29 (96.7)	29 (96.7)
χ^2	0.000	
p-value	1.0	

Site for cannulation was right internal jugular vein in 96.7% cases in both the groups whereas left IJV was catheterized in only 3.3% cases. Site of cannulation between two groups was statistically similar (p>0.05).

Table 3: Comparison of Access time Between two Groups.

Access time (minute)	LMG (n=30)	USG (n=30)	t-value	p-value
Mean	5.12	2.36	7.6	0.001
SD	1.6	1.1		

Mean access time for internal jugular vein cannulation in USG group (2.36±1.1 minute) was observed to be significantly lower as compared to LMG group (5.12±1.6 minute) (p<0.01).

Table 4: Comparison of Number of Attempts Between two Groups.

Attempt	LMG (n=30)	USG (n=30)	χ^2	p-value
1	21 (70.0)	30 (100.0)	10.6	0.005
2	7 (23.3)	0 (0.0)		
3	2 (6.7)	0 (0.0)		
Mean attempt	1.38±0.6	1.00±0.0		

In present study, all the USG guided cannulation were conducted in single attempt whereas only 70% cannulations in landmark guided technique group were conducted in one attempt. Mean number of attempts were documented to be significantly higher in LMG group (1.38±0.6) as compared to single attempt in USG group (p<0.01).

Table 5: Comparison of Complications Between two Groups.

Complications	LMG (n=30)	USG (n=30)	χ^2	p-value
Artery puncture	1 (3.3)	0 (0.0)	1.02	0.313
Arrhythmia	2 (6.7)	1 (3.3)	0.35	0.554
Catheter malposition	2 (6.7)	0 (0)	2.07	0.15
Guide wire problem	2 (6.7)	1 (3.3)	0.35	0.554
Cannulation problem	4 (13.3)	1 (3.3)	1.97	0.16

Arterial puncture was observed in 3.3% cases of LMG group and none in USG group. Though the occurrence of arterial puncture, catheter malposition, arrhythmia, guide wire problems and cannulation problems were observed to be higher in LMG group as compared to USG group, the observed difference was statistically insignificant (p>0.05). Hematoma, hemothorax, pneumothorax and nerve injury were observed in none of the patients amongst participants of two groups.

Table 6: Comparison of Maintenance of Classic head Low Position Between two Groups.

Classic head low position	LMG (n=30)	USG (n=30)
No	1 (3.3)	0 (0.0)
Yes	29 (96.7)	30 (100.0)
χ^2	0.983	
p-value	0.321	

Classic head low position could not be maintained in 3.3% cases of LMG group in present study. However, the observed difference in maintenance of classic head low position between two groups was statistically insignificant (p>0.05).

For patients undergoing cardiac surgeries, placement of central venous catheter is essential as these catheter has multiple pathways through which fluids, blood, or inotropic medication can be administered. Apart from this, central venous catheterization is helpful in monitoring central venous as well as pulmonary arterial pressure. Cardiac venous catheterization in such cases can be done through internal jugular vein or subclavian vein[14]. The catheterization of internal jugular veins can be performed using landmark technique or under the guidance of USG. Use of CVCs may be associated with various adverse effects which can be hazardous and the management of which may be difficult and expensive[15]. The rate of mechanical complications have been reported in 5-19% of patients following CVC whereas infectious and thrombotic complications have been documented in 5-26% and 2-26% respectively[16,17].

Use of real time ultrasound to guide CVC helps in better visualization of desired veins and normal and abnormal anatomic variations prior to and during the insertion of the catheter. This method thus may help in improving success rate and decrease the rate of complications associated with CVC placement[18,19]. The present study was conducted in Department of Anesthesiology, Gandhi Medical College and associated Hamidia Hospital Bhopal on a total of 60 patients scheduled for elective or emergency cardiac surgery to compare the effectiveness of ultrasound guided versus external landmark technique for internal jugular vein access.

With the increase in health care all over the World, life expectancy has increased significantly. It has been estimated that by 2030, approximately 20% of the population of world will be elderly i.e. more than 65

years. Ageing is one of the important determinant of cardiovascular health of an individual. Among elderly, approximately 40% deaths are attributed to cardiovascular disease[20,21]. As a result, proportions of cardiac surgeries are rising. Recently incidence of cardiovascular disease are rising rapidly in younger age group especially among those less than 50 years[22]. In present study, majority of patients in LMG and USG group belonged to >50 years (36.7%) and 41-50 years (46.7%). However mean age of patients of LMG and USG group was 45.83±11.48 years and 43.43±13.38 years respectively.

The findings of present study were supported by findings of Kunhahamed MO *et al* (2019) in which mean age of patients in USG group was 46.74 (±16.36) and that in the AL (anatomical landmark) group was 50.41 (±17.93) years[23].

The mean age of patients in a study by Tempe DK *et al* (2016) who underwent cardiac surgeries was 35.2±14.2 years in landmark group and 36.6±14.9 years in USG group[24]. However, mean age in reference study was much lower as compared to present study. This could be due to difference in level of stress and associated risk factors of cardiovascular disease between the areas of two studies.

Though the incidence of coronary artery disease have been documented to be higher in males as compared to females, but the severity and mortality is high among females as compared to males[25]. In present study, males comprised about 60% and 73.3% patients in LMG and USG group respectively.

Similar to findings of present study, Fathi M *et al* (2016) also noted male preponderance for cardiovascular surgery. In this study, 77.5% patients in landmark group and 60.6% in USG group were males[26].

Determination of weight and neck circumference for central venous catheterization is important as obesity and raised neck circumference may interfere with central venous catheterization. Weight and neck circumference may be predictor of internal jugular vein diameters.

In present study, mean weight of patients of LMG group and USG group was 63.6±8.5 kg and 65.3±16.2 kg respectively. However, mean neck circumference in patients of LMG group was 35.7±4.1and USG group was 36.2±3.9 kg. These findings were concordant to study of Tempe DK *et al* (2016) in which mean weight of control and USG group was 49.3 and 51.3 kg respectively[24]. Similarly, mean neck circumference in LMG group was 35.67±4.773 cms and that in USG group 36.3±3.914 cms in a study by Henjarappa[27].

Site of Cannulation: The right internal jugular vein is usually preferred for central venous catheterization as this vein directly enters into the right ventricle and reflect right atrial pressure. Also, it most accurately reflects the alteration in volume/compliance of right atrium or ventricle, tricuspid or pulmonary valvular dysfunction. Thus, right IJV catheterization is helpful especially in cardiac surgery for monitoring of major alteration during surgery on pre-load, after-load or contractility of heart[1,6].

In our study, right internal jugular vein was the most common site of IJV catheterization i.e. 96.7% cases in both the groups. Left site was cannulated in presence of any contraindication on right side.

All the cases in a study by Ray BR *et al* (2013) underwent IJV catheterization on right side[6,4]. Similarly, most common site of IJV catheterization was right side in majority of patients irrespective of the technique used in a study by Karakitsos[27]. Use of USG guided IJV catheterization have been reported to reduce access time. The access time was defined as time taken from the penetration of skin to the suturing of the catheter. The access time usually correspond with increase in number of attempts of catheterization[28]. In present study, mean access time for internal jugular vein cannulation was significantly lower i.e. 2.36±1.1 minute in USG group as compared to LMG group i.e. 5.12±1.6 minute ($p<0.01$).

The findings of present study were in concordance with the findings of Henjarappa KS *et al* (2014), in which mean access time was significantly shorter in USG group (152.50±63.907 seconds) when compared with landmark technique (323.23±146.197 seconds)[28]. Similar to findings of our study, Tempe DK *et al* (2016) also documented statistically significantly shorter cannulation time in USG group (197.3±116.7 sec) as compared to LMG group (430.2±320 sec)[24].

In another study by Ray BR *et al* (2013), mean venous access time and catheterization time was significantly less in USG as compared to LMG group ($p<0.01$)[29]. USG allow exact visualization of internal jugular vein to be catheterized. Thus, chance of successful cannulation are much higher for ultrasound guided technique. The mean number of attempts for IJV cannulation was significantly lower in USG group (1.00±0.0) as compared to landmark guided technique (1.38±0.6). All the IJV catheterization could be done in single attempt in USG group whereas only 70% catheterization could be done in first attempt in LMG group. The difference was statistically highly significant ($p<0.01$).

The findings of present study were supported by findings of Kunhahamed MO *et al* (2019) in which catheter was inserted on the first attempt in 91.4% patients in USG group and 48.6% cases in landmark group and the difference was statistically significant[23].

Our study findings were concordant to the findings of Karakitsos D *et al* (2006), in which number of attempts

were significantly lower in the ultrasound group as compared to landmark group ($p < 0.001$)[27]. However, our findings were in contrast to findings of Fathi M *et al* (2016) in which 92.7% and 91.8% catheterization in anatomical landmark group and ultrasound group respectively, catheterization was successful on the first try. Overall, mean number of attempts were 1.14±0.51 in the anatomical landmark group and 1.12±0.52 in the ultrasound group. The authors documented no statistically significant difference in number of attempts between two groups ($p>0.05$)[26]. The observed difference between findings of present study and reference study could be due to less expertise of USG technician or radiologist as compared to present study.

Complications following IJV catheterization may range from mild hematoma to severe life threatening complications which may increase the morbidity as well as mortality in these patients. Apart from this, these complications may increase the length of hospital stay and overall cost[1].

Kunhahamed MO *et al* (2019) documented findings similar to present study i.e. they observed acute complications in 14.3% in landmark group and in 5.7% in USG group. Carotid artery puncture was noted in 9% whereas hematoma and catheter malposition was noted in 3% cases each in landmark group whereas hematoma was noted in 6% cases in USG group. Overall, the rate of complications between two groups was statistically insignificant ($p>0.05$)[23].

Saleh AA *et al* (2014) also documented findings similar to present study i.e. Ultrasound guided insertion technique was associated with lower post-insertion complication compared to conventional group[30].

However, Fathi[26] documented significantly higher rate of arterial puncture in landmark guided technique (9.9%) as compared to USG technique (4.4%) ($p<0.05$). Rate of other complications was similar between two groups in reference study ($p>0.05$).

CONCLUSION

Based on the findings of present study, it could be concluded that ultrasound guided technique significantly improve the success rate and decrease the number of attempts required for IJV catheterization. Though the rate of complications were similar statistically in both the groups, but USG guided technique was better in terms of number of attempts, success rate and mean access time as compared to landmark technique.

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