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Comparison of Ultrasound and Anatomic Landmark Guided Techniques for Internal Jugular Vein Cannulation

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Abstract

Background and Objectives: Central venous cannulation is standard of practice in cardiothoracic surgeries for hemodynamic monitoring, administration of fluids and drugs, pacing and so on. The internal jugular vein (IJV) is preferred over other central veins and ultrasound guidance is gaining popularity. This study compares ultrasound-guided (USG)and anatomic landmarks (LMG) techniques for cannulation of right IJV with regard to safety, speed and feasibility. *Methods*: 40 patients were randomly assigned to receive IJV cannulation using either anatomic landmarks or ultrasound-guided techniques. The time for locating the IJV with probe/pilot needle, time for locating IJV with 18G needle,total access time, number of attempts required to successfully cannulate IJV and complications were the parameters studied. The data were analyzed using SPSS 21.0 version. *Results*:-There was statistical difference ($p < 0.001$) between the two groups in the mean time taken for probe to center the ultrasound image/ the 22 G finder needle to locate IJV (5.05sec±SD 1.791- USG, 9.03sec±SD 4.34 – LMG), mean time for 18G introducer needle to puncture IJV(in Group USG was 12.40sec±SD 3.858 whereas in Group LMG, it was 31.70sec±SD 14.430), mean total venous access time(in Group USG was 17.45sec±SD 5.083 whereas in Group LMG it was 41.20sec±SD 16.149). First attempt cannulation was high in USG group (100%) compared to LMG group (50%). *Conclusion*: This study concludes that IJV cannulation is much faster, safer and more successful with ultrasound guidance compared to anatomic landmarks technique.

Keywords: Anatomic Landmarks; Cannulation; Carotid Artery; Complications; Ultrasonography.

Introduction

Catheterisation of central vein is a routine practice in cardiothoracic surgeries for various indications such as hemodynamic monitoring, administration of fluids or drugs,insertion of pacemaker or pulmonary artery catheter and aspiration of air. It may also be needed when peripheral venous access fails [1].

Total parenteral nutrition through sub-clavian vein and external jugular vein popularized central venous cannulation in 19th century itself using Seldinger technique and J-tip guide wire [2]. Internal jugular vein (IJV) cannulation by landmark technique is easy and successful but with 5–10% complication rate. The complications include neck hematoma, carotid artery puncture, pneumothorax, brachial plexus injury or irritation and injury to phrenic nerve, recurrent laryngeal nerve or the stellate ganglion [3–5].

The cannulation of IJV using Ultrasound and Doppler has been reported as early as 1984 [3] and this made the technique safe and rapid with less complication. Cannulation of internal jugular and femoral veins can be performed safely using real-time ultrasonography. The axillary vein cannulation becomes a visible alternative to blind subclavian approaches with the aid of ultrasonography [2]. Several approaches and techniques are practiced for central venous cannulation but percutaneous right internal jugular cannulation is the most

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favoured [1,2,6]. Hence this study was designed to compare the ultrasound guided and anatomic landmarks techniques for cannulation of right IJV.

Aim and Objectives

This study was conducted for the purpose of comparing the two dimensional real-time ultrasound guided technique with the conventional blind anatomical landmark technique for placing central venous catheter in the right IJV of patients posted for major elective cardio thoracic surgeries in terms of the following parameters:

1. The time taken to locate the IJV with the ultrasound probe/pilot needle.
2. Time taken to locate the IJV with the 18G needle.
3. The total venous access time.
4. The number of attempts made for successful IJV cannulation.
5. The complications.

Materials and Methods

This prospective randomized study was conducted in a medical college hospital in South India after institutional ethical committee approved it. Forty patients who needed central venous cannulation for cardio-thoracic surgery, were enrolled in this study after getting written informed consent.They were divided into two equal groups of 20 each (Group USG, Group LMG) by random allocation, using slips in the box technique.Patients in Group USG (Ultrasound group) underwent real time two-dimensional ultrasound guided right internal jugular vein cannulation (n=20). Patients in Group LMG (Landmark group) under went central approach of traditional blind anatomical landmark technique for right IJV cannulation (n=20).

Patients between the ages of 18 to 70 years, scheduled for cardiothoracic surgeries electively, were included in the study. Patients with neck deformities, coagulopathy, local infection, previous history of cannulation, needing emergency cannulation, and history of IJV thrombosis were excluded from the study.

Patients were subjected to standard monitoring such as electrocardiogram (ECG), noninvasive blood pressure (NIBP), pulse oximetry (SpO2), and end tidal carbon dioxide (ETCO2). Peripheral venous access with 16G venflon was established. Midazolam 0.05 mg/kg was given as premedication through intravenous (i.v.) route. Patients were put in 10^0-15^0 Trendelenburg position with a saline bottle between the shoulder blades, head tilted slightly to the left and arms by the side of the body. Asepsis of the right side of the neck was achieved using 5% povidone-iodidine followed by chlorhexidine and sterile sheet draping. The site of skin puncture was anesthetized with 2ml of 2% lignocaine infiltration.

In group USG, IJV was identified using portable ultrasound machine sonoray DS 20 with a 7.5 MHz linear probe. After cleaning the probe with normal saline and chlorhexidine, sterile glove was applied over it. The contact surface was exposed by a small incision over the glove and gel was applied. The operator utilized the real time two dimensional (2 D) ultrasound image to identify the IJV, which was easily compressible with the probe, non-pulsatile and got markedly enlarged during Valsalva manoeuvre in comparison with carotid artery which was more medial, noncompressible and pulsatile.

The operator centered the IJV on the screen and introduced a 18G thin-wall needle with heparin saline loaded 5ml syringe from the superior aspect and the midpoint of the high frequency linear probe (out of the plane technique). The tip of the needle was identified using the real-time ultrasound image and cannulation attempted. The anterior wall of the IJV getting compressed can be visualized, before the needle entered the vessel. The entry of needle into the lumen of the vessel was confirmed by ultrasound as well as by aspiration of dark venous blood in the heparin loaded syringe. The probe was stabilized by an assistant, while the guide wire was inserted by the operator. Constant monitoring of the image aided the needle tip to lie in the middle of the IJV lumen, thereby enabling the guide wire insertion under vision. Application of dilator, insertion of a 7Fr triple-lumen catheter over the guide wire and securing the catheter were followed as per standard protocol using Seldinger technique.

In Group LMG the classic central approach for IJV cannulation was done. The carotid artery was felt and pushed medially. The apex of the triangle formed by the two heads of the SCM muscle and clavicle was identified. A 22G finder needle with a 5ml heparin saline loaded syringe was first advanced through the skin from this point, at an angle of 45 degrees from the coronal plane in the direction of ipsilateral nipple to locate the IJV. Once venipuncture occurred with the finder needle, demonstrated by the free aspiration of dark venous blood, the operator noted the direction and depth

of the finder needle before withdrawing it. Then the 18G needle on a 5ml heparin saline loaded syringe was introduced in the identical plane and venipuncture was attempted in the same direction and depth. The remaining steps were followed in a similar manner to that of USG group.

If venipuncture did not occur at the initial thrust, maintaining the back pressure, the needle was withdrawn slowly. If the first attempt was not successful, subsequent attempts were directed slightly laterally or medially to the initial thrust after reassessment of patient position, landmarks, techniques and the carotid artery position. If venipuncture could not be established with 18G needle after insertion up to a depth of 0.5cm beyond that of a successful finder needle insertion, in the same direction in LMG group or inability to locate the IJV with 18G needle for more than 60 seconds in USG group, the attempt was taken as a missed attempt.

Then a fresh attempt was made after withdrawing the 18 G needle up to the skin. If the guide wire could not be passed easily beyond the tip of the 18 G needle, free backflow of blood was reestablished by removing the guide wire and attaching the syringe. If this also failed, the 18G needle was withdrawn and a new attempt was made. If venipuncture or cannulation was not successful after 3 consecutive attempts with the 18G needle or if the operator was unable to cannulate in less than 30 min or the development of significant hematoma (> 2cm in any dimension) due to arterial puncture, it would be considered as failure. The time taken (in seconds) from the point of skin contact of the probe till centering real-time ultrasound image of the IJV on the screen was considered as probe time in USG group. The time needed for setting up of the ultrasound machine was not accounted.

The time taken (in seconds) from the point of skin contact of the 22 G finder needle till free aspiration of dark venous blood was noted as finder needle time in LMG group. The time spent to define the anatomical landmarks was not included.

The time taken with the 18 G needle to locate the IJV, was the time required (in seconds) from the point of skin contact of the 18G needle till the free aspiration of dark venous blood during the final attempt that resulted in successful cannulation in both the groups. In case of multiple attempts, only the time when the needle was placed on the skin or advanced was taken into account.

The total venous access time was the time taken with the probe/ the finder needle (22G) to locate the IJV (in seconds) plus the time taken with the 18 G needle to locate the IJV (in seconds).

The total number of attempts made for successful cannulation of the IJV including the missed attempts were recorded.

Failure to cannulate was also accounted and was followed by an attempt to cannulate the right IJV by alternate technique or left IJV by either central landmark approach or by ultrasound guided technique.

Carotid artery puncture during the procedure was documented and managed with compression for 5 minutes to avoid hematoma formation.The formation of significant hematoma (>2cm in any dimension) was documented. Other complications such as nerve injuries, haemothorax, pneumothorax, malposition and ectopics were looked for. Another investigator made all these observations using stopwatch.

Statistical Analysis

By using the values of mean difference and standard deviation of venous access time in both groups from a previous study [5], the required sample size was derived as 16 per group using n Master software version 2.0 with power of 90% and alpha error of 5%. Considering the dropouts, a sample size of 20 per group was chosen for this study. Using SPSS software version 21.0, the data were analyzed statistically by computing percentages and descriptive statistics viz., mean, standard deviation, and standard error of mean. The difference in mean between the ultrasound-guided (USG) technique and landmark-guided (LMG) technique was tested using independent Student's t-test and chi-square test. When p value is ≤ 0.05, it was considered to be significant statistically.

Results

The two groups showed statistically no significant differences in age, sex, height and weight (Table1-3). Statistically significant difference was noted between the two groups ($p < 0.001$) in the mean time needed to locate the IJV either by the probe (USG group) or the 22G finder needle(LMG group).The difference between the two groups, in the mean time for the 18G introducer needle to puncture IJV was also statistically significant ($p < 0.001$). Significant statistical difference was there between the two groups in the mean total venous access time too ($p < 0.001$) (Table 4). All the cases in the USG group

were cannulated in first attempt whereas some of the patients in LMG group needed more than one attempt (Table 5). The complication rate was much less in USG group (Table 5).

Table 1: Agewise distribution of the subjects based on their sex[N = number of patients]

Age (Years)	Ultra Sound–Guided Technique Male N (%)	Female N (%)	Total N (%)	Landmark–Guided Technique Male N (%)	Female N (%)	Total N (%)
< 20	1(9.1)	1(11.1)	2(10.0)	-	-	0(0.0)
21 – 30	1(9.1)	1(11.1)	2(10.0)	1(9.1)	1(11.1)	2(10.0)
31 – 40	2(18.2)	4(44.4)	6(30.0)	3(27.3)	3(33.3)	6(30)
41 – 50	4(36.4)	2(22.2)	6(30.0)	2(18.2)	4(44.4)	6(30)
51 – 60	-	-	-	2(18.2)	1(11.1)	3(15.0)
61 – 70	3(27.3)	1(11.1)	4(20.0)	3(27.3)	0(0)	3(15.0)
Total	11(100)	9(100)	20(100)	11 (100)	9(100)	20(100)

Table 2: Statistical inference of age, height and weight

	Group statistics Group	N	Mean	SD	SEM	Unpaired t test	P value
Age (in yrs)	Ultrasound	20	42.35	14.41	3.223	0.880	0.384 NS
	Landmark	20	46.05	12.07	2.699		
Height (cms)	Ultrasound	20	158.45	7.864	1.758	0.840	0.406 NS
	Landmark	20	160.70	9.044	2.022		
Weight (kgs)	Ultrasound	20	56.90	6.299	1.408	0.339	0.737 NS
	Landmark	20	57.75	9.296	2.079		

NS - No significant difference between ultrasound and landmark at 95% [P>0.05] in age, height and weight

Table 3: Statistical inference of Sex

	Ultrasound N	%	Landmark N	%	Chi square test	P value
Male	11	55	11	55	0.000	1.000NS
Female	9	45	9	45		

NS - No significant association between Ultrasound and Landmark at 95% [P > 0.05] in sex.

Table 4: Statistical inference of Time for the probe/finder needle, time for the 18G introducer needle and total time access

	Group statistics Group	N	Mean	SD	SE	Unpaired t test	P value
Time For probe/ Finder needle(Sec)	Ultrasound	20	5.05	1.791	.400	4.047	0.001
	Landmark	20	9.30	4.342	.971		
Time for 18G needle (sec)	Ultrasound	20	12.40	3.858	.863	5.779	0.001
	Landmark	20	31.70	14.430	3.227		
Total Time (sec)	Ultrasound	20	17.45	5.083	1.137	6.274	0.001
	Landmark	20	41.20	16.149	3.611		

There is a highly significant difference between Ultrasound and Landmark Techniques in time for probe/ finder needle (sec), time for 18G needle (sec) , total time access(sec) at 95% [P < 0.05]

Table 5: Statistical Inference in CVC attempts and complications

		Ultra Sound N	%	Land Mark N	%	Chi Square	P Value
Number of attempts	First attempt	20	100	10	50	13.33	0.001
	Second attempt	0	0	9	45		
	Third attempt	0	0	1	5		
Complications	Carotid puncture	1	5	8	25	7.025	0.008
	Nil complication	19	95	12	75		

There is association between Ultrasound and Landmark technique at 95% CI
[P =0.001] in first attempt, second attempt and third attempt .
There is a significant association between Ultrasound and Landmark at 95%CI
[P =0.008] in carotid artery Puncture.

Discussion

Various studies and data are available in literature explaining different approaches and techniques of central venous cannulation [3,7–12]. Most of the studies showed that IJV cannulation through central approach was preferred due to easy identification of surface landmarks. Also the preference of right side over the left was recommended,due to shorter and straighter course of the vein, which would lead to easy cannulation. Ultrasonography aids in successful and quicker cannulation with lesser complications.

In this study, we applied two different techniques of right IJV cannulation but through same approach i.e. central approach. Though the knowledge about neck anatomy is vital, in practice surface markings cannot be relied upon always in locating the IJV, as it has considerably varying position particularly in a lateral plane [2].

Sulek et al [13] has stated that more than 40 degree of head rotation to the left has changed the relationship of IJV with CA from lateral to anterior. This has resulted in more carotid artery punctures. Metz et al[14] studied various techniques using ultrasonography and found that no one technique scored over others ,especially breath holding, rotation of the head, or extension of the neck had no influence on IJV cannulation rates. Valsalva manoeuver increased the diameter of IJV by about 126% as per the study done by M.Leon Skolnick [15] but was not used for the facilitation of IJV cannulation in our study.

The difference between probe time and finder needle time was statistically significant ($p<0.0001$) in our study. No other studies had demonstrated this. The time taken in preparation of the ultrasound machine and sterilizationof the probe was not taken into consideration in USG technique and the time taken to define the anatomical landmarks not included in LMG technique.

The local anesthetic infiltration over the SCM triangle before cannulation was not taken into account and the time taken for aseptic precautions of operator and patient was also not considered in either of the group. The time for 18G introducer needle to locate the IJV was shorter in USG technique compared with LMG technique ($p<0.001$).

Hence the total access time corresponded with an increase in number of attempts and was lesser in USG technique compared with LMG technique and the difference was statistically significant ($p<0.001$). This correlates with study conducted by Denys BG and Uretsky BF [16]. Ray et al [17] also had similar observation.

Cannulation was 100% successful in first attempt in our study using USG technique(even though CA was punctured in one case, IJV was cannulated successfully after repositioning the needle). LMG Group had a maximum of 3 attempts. 50% of the patients had first attempt cannulation, 45% had 2 attempts and 5% had 3 attempts. This was similar to the studies of Hatfield A and Bodenham A [11], Denys BG and Uretsky BF [16], Theodoro et al [18], Farrel J and Gellens M [19], Mallory etal [20]and Troianos et al [21]who had all demonstrated that ultrasonagraphic guided cannulation decreased the number of attempts.

The incidence of CA puncture in our study was significantly lesser in USG group than in LMG group ($p<0.001$) and this was similar to the observations by Bannon et al [2], Denys et al [3],Machi et al [10], Hatfield A and Bodenham A [11], M. Leon Skolnick [15], Ray et al [17]and Troianos et al [21], Though other complications like pneumothorax, nerve injuries, Horner's syndrome, malposition, ectopics were reported in some of the studies [3,18], none of these complications were there in our study. Bed side chest x-ray was taken in all patients post operatively in ICU for confirmation of catheter position in superior vena cava and found to be normal.

Though the landmark technique results in many complications, they could be minimised with experience and by taking adequate caution. The limitations of 2-D such as apparent entry of needle into the lumen though actually it is not, dynamic changes with respiration and cardiac activity could be overcome by higher resolution 3 D and color Doppler machines.However the cost is a factor limiting its use in the day to day practice in most of the hospitals.

Conclusion

This study concludes that ultrasound-guided technique is superior to the traditional landmark-guided technique for the cannulation of right internal jugular vein in terms of speedy access of the vein for cannulation, more successful cannulation with minimal number of attempts and least discomfort to the patients.

The complications were less serious during central venous cannulation of right IJV using ultrasound technique.

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