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

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Abstract

Introduction: Conventionally central venous catheter is done utilising landmark technique. With increased availability of portable USG units, USG-guided intervention is fast gaining acceptance as a valuable tool in the critical-care setting. We designed this study to compare two methods of CVC insertion in terms of time taken, number of attempts, success rate and incidence of complications. This study will help us evaluate real time ultrasound in comparison to landmark technique. *Material and Methods:* 100 ASA I and II patients of either sex of ≥ 18 years of age, admitted to ICU or underwent surgery, requiring CVC placement were included in the study. Patients were randomly divided into two groups. Primary outcome measures were Successful insertion of a CVC. Secondary outcomes were (a.) Number of attempts for successful insertion of CVC (b.)Time taken to insert, (c.) Failure rate in insertion (d.) Incidence of complications. *Result*: The study was conducted in patients with a variety of disease processes. The distribution of age and sex was comparable in both the groups. Success rate was more in case of USG guided CVC insertion than landmark technique. In landmark technique successful cannulation was done in 86% patients vs 98% in USG group. The time taken during the procedure between group A (landmark technique) was 42.59 ± 16.54 seconds which was higher than the time taken to catheterised by ultrasound guided technique 16.69 ± 9.80 seconds. p value was found to be less than 0.001, which was statistically significant. In group A incidence of hematoma formation was 14% and intra-arterial insertion of needle was 6% out of 20% overall complications. In group B incidence of hematoma formation was 8% and intra-arterial cannulation was 2% out of overall 10% complications. It was found that overall complication was more in group A patients than group B patients. But P value was found to be 0.161, and was statistically not significant. *Conclusion*: Considering the findings of the study, we concluded that USG guided CVC insertion has a better success rate, less failure, required less number of attempt and time taken to insert the CVC was significantly less. However, there was less complication with USG guided CVC insertion in present study, but it did not achieve statistical significance

Keywords: Ultrasound guided catheterization; Central venous catheter; Seldin.

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Introduction

Central venous catheter (CVC) placement has become integral part in intensive care units. It is an innovative technique developed by Seldinger for insertion of large bore catheter. Access to central circulation using CVC is very useful in CVP measurement for evaluating hemodynamic

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status of the patient. CVC may be required for administration of hyperosmolar or vasopressor, parenteral nutrition, rapid infusion of fluid boluses or continuous monitoring of various physiological parameters[1,2]. CVC is also indicated when peripheral lines catheter insertion is not possible[3].

Conventionally, CVC insertion is done using landmark technique (LMT) in internal jugular vein, subclavian vein or femoral vein. IJV is more commonly used because of its ease of accesssibility and less chances of complications. However infection rate has been reported to be least in subclavian approach[4,5]. Many anatomic landmark guided techniques for IJV puncture have been described since 1966[6,7]. With increased availability of portable USG units, USG-guided intervention is fast gaining acceptance as a valuable tool in the critical-care setting[8]. Ultrasonography-guided procedures can save time and increase the accuracy, safety and efficacy of many interventions commonly performed in ICUs, including CVC insertion. There is abundant evidence that USG-guided catheter placement increases the safety and efficiency of the procedure. The benefits of using USG guidance over LMT for CVC insertion have been reported as far back as 1978, and the body of literature supporting the use of USG continues to increase[9]. The advantages of USG guidance over LMT in CVC insertion include risk reduction[5,10,11], improved success rates[5,11,12], quicker insertion, a reduction in the number of attempts required and the ability to cannulate in difficult situations[6,7,13-18]. Hence it designed this comparative study of Real-time ultrasound-guided catheterisation of the internal jugular vein with the landmark technique.

Aims and Objectives

Primary outcome measures were Successful insertion of a CVC.

Secondary outcomes were (a.) Number of attempts for successful insertion of CVC (b.) Time taken to insert, (c.) Failure rate in insertion (d.) Incidence of complications

Material and Methods

After obtaining approval from Ethical Committee, the present study was conducted in Department of Anesthesia of Teerthanker Mahaveer Medical College & Research Centre, Moradabad. After taking prior informed consent from the either patient or patient's relative we included 100 ASA I and II patients of either sex of ≥ 18 years of age, admitted to ICU or underwent surgery from August 2017 to August 2018, requiring CVC placement were included in the study. The patients not giving consent, patients with coagulopathies or prolonged bleeding time [International Normalisation ratio>1.5, platelets count<50,000/mm^3], infection at the site of needle insertion, patients with CVC placement for cardiopulmonary resuscitation or trauma patients in whom the cervical spine could not be cleared clinically or radiologically before line insertion were excluded from the study.

The patients were randomly divided into two groups using computer generated random number table. A minimum number of 50 patients were enrolled in each group after taking consent from patient or his/her relative.

Group A (n = 50): Anatomical land mark technique central approach

Group B (n = 50): USG guided two person technique

In group A the CVC insertion done by Landmark technique and in group B CVC was inserted by USG guided technique.

Intervention and approach

The Operator had an experience of insertion of more than 10 CVC in each group. The right internal jugular vein was taken as first choice for cannulation. Left IJV could be cannulated only if right IJV was not available for cannulation due to the presence of a previously inserted CVC, dialysis catheter, infection, haematoma formation by previous attempt. CVC insertion using the anatomical technique had been performed through the central approach. USG guided CVC insertion had been performed with two person technique.

Landmark Technique

The patient was positioned in Trendelenberg position to decrease the risk of air embolism. This also helps to distend the IJV. Under all aseptic conditions triangle formed by two head of sternocleidomastoid muscle and the clavicle was identified. Infiltration with local anaesthetic was given at the apex of the triangle. A 25 gauge needle was advanced along the medial border of the lateral head of sternocleidomastoid towards the ipsilateral nipple, at an angle of 30° to the skin. Aspiration of venous blood confirmed the vein location. An 18 gauge needle was introduced along the same path as locator needle. When free flow of blood was

achieved, vein puncture confirmed and a guide wire introduced. The needle was removed and a dilator advanced over the wire. Then dilator removed and the catheter advanced after flushing all the ports with saline and distal ports capped except the central through which guide wire passed. The guide wire then removed and the line connected to IV line. The CVC then secured properly and sterile dressing applied.

USG Guided Approach

A portable ultrasound machine "MTURBO®" with a 7.5-10 MHz, 38 mm linear array probe used. Aseptic measures included cleaning of the lead and transducer with an antiseptic solution and gel was used to cover the probe. After patient positioning the neck was draped and sterilized with antiseptic solution. Keeping in mind the anatomical landmarks, the transducer was placed at right angle to the vessels at the tip of the triangle formed by the two heads of the sternocleidomastoid muscle and the clavicle.

The vein was recognised by its large lumen and confirmed by checking its easy compressibility. Artery was distinguished by its thicker walled and pulsatile nature. Transducer was placed in such a way that vein would be seen at centre of ultrasound monitor. After infiltration with local anaesthetic [2 ml of 1% lignocaine] if patient was not sedated, the introducer needle was directly inserted along the centre of the probe towards the centre of the vein, under USG guidance. On the monitor, the needle was seen either puncturing the vein or compressing the vessel. Once puncture of the vein occurred, the modified Seldinger technique followed as described above in anatomical approach to insert a CVC.

No. of attempts and Failure

The procedure considered a failure if the operator was unable to cannulate the vein within three attempts. An attempt was defined as the introducer needle entry into the skin and its removal from the skin. If the initial method was unsuccessful after a maximum of three attempts, an alternative method was used. If three unsuccessful attempts were made by anatomical landmark technique then USG guided technique was used or help taken from more experienced operator or an alternative site chosen.

Time Taken for the Procedure

For Anatomical land mark technique: Time taken to perform CVC was measured from insertion of the pilot needle for vein location to easy aspiration of blood through the central venous catheter. For USG guided technique:

Time taken to perform CVC was measured from the beginning by transducer to easy aspiration of blood through the central venous catheter.

Observations

All patients in both the groups were independently observed for the following effects:

A) Successful insertion of a CVC, B) Time taken during the procedure, C) Number of attempts in both the groups, D) Number of failures in both the groups, E) Incidence of complications such as hematoma formation, pneumothorax, artery puncture, nerve injury etc.

Statistical Analysis

Statistics

Results were statistically analysed using latest version of SPSS 16.0. The means of the continuous variables between two groups were compared using the student t-test and categorical variables were compared using chi-square test. A p-value of < 0.05 was considered statistically significant.

Sample Size

A sample size of 50 in each group was based on power analysis in which alpha level was fixed at 0.05, anticipated effect size (Cohen's d) of 0.6 and for a desired statistical power level of 0.8, a minimum required sample size per group was calculated to be 45 and minimum total required sample size was calculated to be 90.

Data Analysis

Continuous data was presented as means ± standard deviation. Ordinal data are presented as medians (quartiles), and categorical data are presented as numbers and frequencies. Demographic Data between the groups were analyzed using chi square, unpaired t-test etc.

Results

The study was conducted in patients with a variety of disease processes. The distribution of age and sex was comparable in both the groups so it did not influence our result.

Table 1 shows distribution of patients according to sex in group A and group B was comparable.

Table 2 demonstrates the distribution of age between two groups. The difference of the Mean was not statistically significant.

Table 3 demonstrates the successful insertion of CVC in each group.

Table 4 depicts the time taken during the procedure between group A and group B. Among the two technique time taken to catheterized for landmark technique was 42.59±16.54 seconds which is higher than the time taken to catheterised by ultrasound guided technique 16.69±9.80 seconds. p value was found to be less than 0.001(CI -31.43 to -20.37), which was statistically significant.

Table 5 depicts incidence of individual complications in group A and group B.

In group A incidence of hematoma formation was 14% and intra-arterial insertion of needle was 6% out of 20% overall complications. In group B incidence of hematoma formation was 8% and intra-arterial cannulation was 2% out of overall 10% complications.

It was found that overall complication was more in group A patients than group B patients. But p value was found to be 0.161, and was statistically not significant.

Table 6 demonstrates comparison of the two groups.

In group A CVC was successfully inserted 43 (86%) out of 50 patients, and in group B CVC was successfully inserted in 49 (98%) out of 50 patients. P-value was 0.027 and was statistically significant. Similarly, in group A failure occurred in 7 (14%) out of 50 patients, while in group B failure occurred in 1 (2%) out of 50 patients. *p*-value was 0.027 and was statistically significant.

In group A CVC was inserted successfully in one attempt in 8 patients, two attempts in 24 patients and three attempts in 12 patients, whereas in group B it was inserted in one attempt in 26 patients, two attempts in 20 patients, in three attempts in 3 patients. *p*-value was <0.001, which was statistically significant. In group A time taken to insert CVC Mean ±SD was 42.59 ± 16.54 seconds compared to group B Mean±SD was 16.69 ± 9.80 seconds. *p*-value found to be <0.001 which was statistically significant.

Complication was found in 10 patients out of 50 in group A, and 5 patients out of 50 in group B. P-value found to be 0.161 which was not statistically significant.

Table 1: Distribution of Patients According to Sex in the Groups

Sex	Group A		Group B		Test of significance
	N	%	N	%	
Male	27	54.0	29	58.0	$\chi 2=0.162$
Female	23	46.0	21	42.0	$p= 0.687$
Total	50	100.0	50	100.0	

Table 2: Distribution of Age Between Group A and Group B

Age (in years)	Group A		Group B		Test of significance
	N	%	N	%	
<30	15	30.0	23	46.0	
30–44	17	34.0	8	19.0	t= 0.8845
45–59	8	16.0	12	24.0	
>60	10	20.0	7	14.0	Standard error of difference=2.980
Total	50	100.0	50	100.0	
Age (Years)	Group A		Group B		$p= 0.3786$
Mean±SD	39.9 ± 15.80		36.92 ± 17.83		

Table 3: Successful Insertion of Central Venous Cathrter

	Group A		Group B		
	N	%	N	%	
Success	43	86.0	49	98.0	$\chi 2=4.89$
Failure	7	14.0	1	2.0	
Total	50	100.0	50	100.0	$p=0.027$

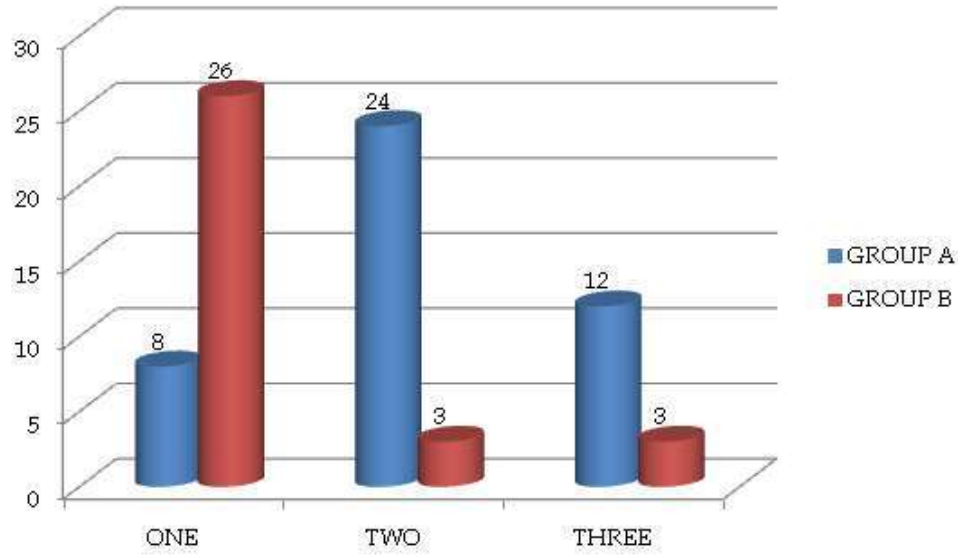

Fig. 1: Shows the Graphical Representation of Number of Attempts Taken to Insert Central Venous Catheter in Both the Groups.

Table 4: Time Taken During the Procedure in Successful Patients

Time in seconds	Group A		Group B		
	N	%	N	%	
<15	0	0.0	20	40.82	
15–29	10	22.73	28	57.14	t value=9.297
30–44	20	45.45	0	0.0	*p* value<0.001
45v60	10	22.73	0	0.0	
>60	3	9.09	1	2.04	95% CI 31.43 to 20.37
Total	43	100.00	49	100.00	
Mean±SD	42.59 ± 16.54		16.69 ± 9.80		

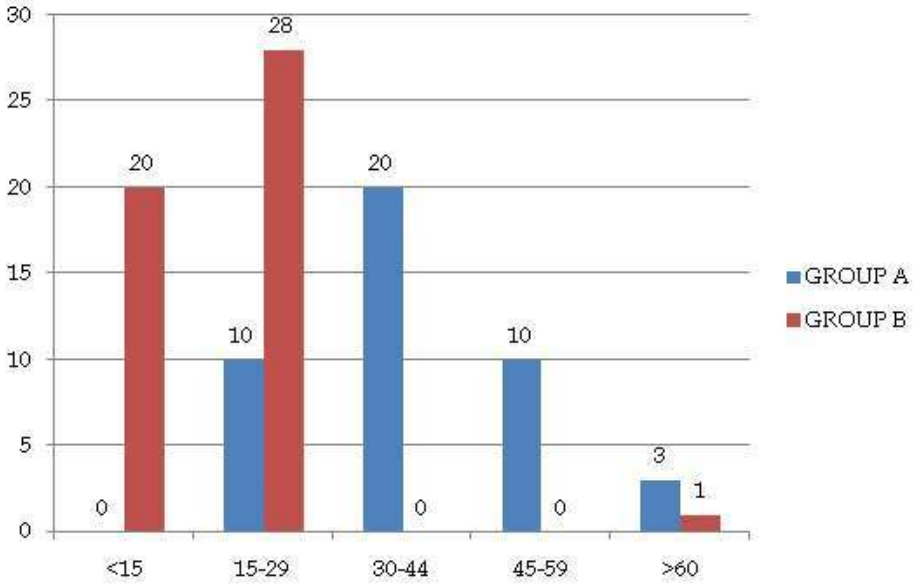

Fig. 2: Graphical Representation of Time Taken During the Procedure in Both the Groups in Successful Patients

Table 5: Incidence of Individual Complications in Group A and Group B

	Complication		No Complication		
	Hematoma	Intra-Arterial	N	%	
Group A	14%	6%	40	80%	$\chi 2=1.96$
Group B	6%	4%	45	90%	$p=0.161$

Table 6: Comparison of the Two Groups Considering All the Parameters

	Success/ Failure (No. of patients)	No. of Attempt	Time Taken (in seconds)	Complication (No. of patients)
Group A	Success = 43 (86%) Failure = 7 (14%)	One-8 (18.60%) Two-24 (55.81%) Three-12 (25.58%)	Mean±SD 42.59 ± 16.54	Complication-10 patients No complication-40 patients
Group B	Success = 49 (98%) Failure = 1 (2%)	One-26 (53.06%) Two-20 (40.82) Three-3 (6.12)	Mean±SD 16.69 ± 9.80	Complication-05 No complication-45
Significance	*p*-value 0.027	*p*-value <0.001	*p*-value <0.001	*p*-value 0.161

Discussion

Benefits and utility of CVC placement is well established but evidences has shown that landmark based approach in CVC insertion is associated with significant complications, including arterial puncture, hemothorax, pneumothorax, brachial plexus injury, hematoma formation, catheter malposition[13,14]. A review by Le frant et al.[15] described an overall complication rate of 15% in landmark technique. Central venous catheter cannulation is associated with a number of technical complications. The common ones are arterial puncture (10.6–13%)[16,17], hematoma formation (4–8.4%)[16,17], brachial plexus injury (1.7%)[18], pneumothorax (0–6.6%)[19,20], and hemothorax (1%)[4]. The procedure is also associated with some rare but serious complications, including arterial rupture (<1%)[21], arteriovenous fistula formation (0.2%)[22], guidewire loss (0.5%)[23], chylothorax and chylopericardium.

Various studies have shown that incidence of success is more in case of USG guided CVC insertion than landmark technique.[5,12,18] In case of USG guided CVC catheterisation the path of needle can be visualised. Thus it becomes easier to perform catheterisation under ultrasound guidance. In case of landmark technique anatomic aberration cannot be ruled out so there is more chance of failure and complication. The image quality offered by 2-dimensional USG allows the user to clearly see variations in anatomy and to assess the patency of a target vein.

Similar results were reported by G.C. Clagett[24], J. Leung *et al.*[25] and Dimitrios karakitsos *et al.*[26] . They concluded that ultrasound-guided catheterisation of the internal jugular vein in critical care patients is superior to the landmark technique and therefore should be the method of choice in these patients. C. Froehlic *et al.*[27] demonstrated that there was no difference in the overall success rates (88.2% LM vs. 90.8% US) between landmark and USG guided technique. Ninfa Mehta *et al.*[28] found that the ultrasound was significantly (p=0.02) more successful at eventually placing CVCs into a internal jugular vein with a relative success (RS) rate of RS=1.19, higher success rate for the USG78% compared with the LMT- 55%. In present study success rate was more in case of USG guided CVC insertion than LMT. In LMT successful cannulation was done in 86% patients which was in agreement to previous studies. Whereas cannulation was done in 98% patients, and was in accordance to previous studies. p-value was 0.027 and was statistically significant. Hence it was concluded that USG guided CVC insertion is better than landmark technique.

In present study it was found that failure occurred in 14% patients in landmark technique, whereas 2% failure occurred in USG guided technique. p-value was 0.027 and was statistically significant. Our result was in accordance with previous studies.

It has been shown in many studies that use of ultrasound decreases number of attempts.[25,29-31] Variations in external landmarks and internal anatomy can make landmark-guided cannulation challenging.

E.Koski *et al.*[31] compared the conventional method with the ultrasound-aided technique. The venous lumen was reached with fewer punctures while using the ultrasound-aided technique. Similarly, Randolph *et al.*[30] evaluated the effect of real-time ultrasound guidance using a regular or Doppler ultrasound technique for placement of central venous catheters. They found that USG significantly decreases the need for multiple catheter placement attempts when compared with the standard LMT.

C. Froehlic *et al.*[27] demonstrated median number of attempts were fewer with USG for all CVCs attempted. Ultrasound identified the vein size and location, anomalies, and vessels patency, thus avoiding futile attempts in patients with absent or thrombosed veins and congenital anomalies such as persistent left superior vena cava.M. Bruzoni *et al.*[32] also compared and reported success at first attempt in 65% of patients in the ultrasound group vs 45% in LMT (p = 0.021). Ultrasound reduced the number of cannulation attempts necessary for venous access.

In the present study out of 50 patient's cannulation was done in 1 attempt in 8 (18.60%) patients, two attempts in 24 (55.81%) patients and three attempts in 11 (25.58%) patients by LMT. In USG guided technique CVC inserted in one attempt in 26 (52%) patients, in two attempts in 20 (40%) patients, and in three attempts in 3 (6%) patients out of 50 patients. There was a statistically significant difference between the two groups. It was found in previous studies that use of USG decreases the time taken to puncture IJV as compared to traditional LMT. U. Teichgraber et al[33] showed that access time was markedly shorter with the sonographically guided technique (mean, 15.2 sec: range, 8-76 sec) than with the anatomic LMT (mean, 51.4 sec; range, 3-820 sec)/p = .001). In ultrasound lumen of vein could be visualised which probably reduces the time taken from skin puncture to aspiration of blood. Thus time taken to cannulate the vessel decreases.

C. Froehlic *et al.*[34] demonstrated mean time with USG (median 919 seconds vs. 405 seconds, p = 0.02) and Henjarappa *et al.*[35] reported the mean access time in USG technique lesser than in LMT. Similarly in the present study it was found that mean time taken to cannulate IJV was significantly lower in USG guided technique as compared to LMT. In group A time range was 18-96 seconds while in group B it was between 8-76 seconds. In group A time taken to catheterise was Mean± SD=42.59 ± 16.54, was significantly higher as compared to group B, which was Mean± SD=16.69 ± 9.80.

Randolph *et al.*[12] evaluated that ultrasound guidance significantly decreases complications during catheter placement. U. Teichgraber *et al.*[31] demonstrated that complications were fewer with USG (neck hematoma, 2% versus 10%; plexus irritation, 4% versus 6%; carotid artery puncture, 0% versus 12%).J. Leung *et al.*[26] observed that there was a 10.8% complication rate, with 16.9% complications in LMT and 4.6% in the ultrasonographic group, a difference of 12.3%. However in the present study we found that out of 50 patient's complications occurred in 10 (20%) patients in LMT while in 5 (10%) patients in USG guided technique. Although the difference in incidence of complication between two groups was not statistically significant, the incidence was less in USG guided group.

Limitations

As with most of the studies our study is not exceptional. It has some limitations and weaknesses which were inevitable. It could not be double blinded, this limitations has an inborn chance of being biased. The study was randomised on the basis of technique of insertion of central venous catheter. However, the strength of the study was the sample size, and populations with various disease process.

Conclusion

Considering the findings of the study, we concluded that USG guided CVC insertion has a better success rate, less failure, required less number of attempt and time taken to insert the CVC was significantly less. However, there was less complication with USG guided CVC insertion in present study, but it did not achieve statistical significance.

Hence, we suggest that as per the NICE guideline Central Venous Cannulation should be done under the USG guidance, if available especially in patients who are critically ill. This will increase the success rate; decrease the number of attempts, duration of insertion, duration of insertion and complications.

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Conflict of interest: None

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