RESEARCH ARTICLE

Comparison of Anterior and Posterior Approach of Percutaneous Catheterization of Internal Jugular Vein under Real Time Ultrasound Guidance in Critically Ill Patients: A Prospective Randomized Study

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Abstract

Introduction: Central venous catheterization is a vital intervention in critically ill patients. The proper route of insertion is essential for its success. The purpose of this study was to compare the procedural parameters and complications associated with anterior and posterior approaches to internal jugular vein catheterization under real-time ultrasound guidance in critically ill patients.

Materials and methods: In this prospective randomized study, 90 patients admitted in various ICUs were randomly allocated two groups of 45 each, including both males and females aged between 18 and 80 years of age requiring central venous catheterization for various indications. Demographic data was comparable between both groups. The first attempt success rates, venous visualization time, venous puncture time, duration of catheterization, and complications of each route were compared.

Results: The first attempt success rates were comparable between both groups. The venous visualization time was 38.52 seconds in group I and 14.65 seconds in group II ($p < 0.001$). The venous puncture time and the duration of catheterization was found to be 47.60 sec and 2 minutes in group I, respectively, and 24.16 sec and 1 minute 32 sec in group II, respectively ($p < 0.001$). No statistically significant differences were found between the two groups in terms of incidence of carotid arterial puncture, hematoma formation, and catheter displacement.

Conclusion: It was concluded that the posterior approach is better than the anterior approach of ultrasonogram (USG) guided internal jugular vein catheterization as it improves the accuracy, reduces the access time and duration of catheterization, and fewer incidences of immediate complications like carotid arterial puncture and hematoma formation.

Keywords: Anterior approach, Critically ill patients, Posterior approach, Internal jugular vein cannulation, Ultrasound.

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Introduction

Central venous catheterization is an integral part of invasive monitoring and management in the modern era. It is a vital intervention in critically ill patients and in major elective and emergency surgeries, so is an essential skill for critical care physicians.

The choice of central venous catheter insertion sites will depend on the indications, relative contraindications, risk of complications, patient factors predicting difficult cannulation, and the clinical conditions. The technique for central venous catheter insertion is the same for single, double, and triple lumen catheters, as well as dialysis lines.

Common Indications for Central Venous Cannulation

- Hemodynamic monitoring.
- For long-term hyperalimentation.
- For rapid restoration of blood volume in cases of acute blood loss.
- Administration of drugs and hypertonic solutions likely to induce phlebitis.
- Temporary cardiac pacemaker.
- Hemodialysis.
- Lack of peripheral venous access.

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Absolute Contraindications to Central Venous Cannulation

- Infection at the site of cannulation.
- Abdominal trauma and inferior vena cava disruption where femoral vein cannulation has to be avoided.
- SVC syndrome, where cannulation of the internal jugular, external jugular, antecubital and subclavian vein has to be avoided.

Relative Contraindications to Central Venous Cannulation

- Inexperience, unsupervised operator.
- Distorted local anatomy.
- Coagulopathy.
- Previous radiation therapy.
- Suspected proximal vascular injury.

Predictors of Difficult Cannulation

- Emergency placement.
- Obesity.
- Bleeding diathesis.
- Intubated patients.
- Hypotensive/hypovolemic.
- History of previous difficult cannulation.

Complications

- Major arterial puncture and hematoma (commonest).
- Pneumothorax, hemothorax, hydrothorax, and chylothorax.
- Arrhythmias, cardiac tamponade, and cardiac arrest.
- Bacteremia.
- Kinking and displacement of catheter.
- Horner's syndrome and injury to 9–12 cranial nerves.
- Tracheal puncture and endotracheal tube cuff puncture.
- Superior vena cava thrombosis and obstruction.
- Aortic catheterization and dissection.
- Air and catheter embolism.

The proper choice of insertion is essential for success. The advantage of internal jugular vein cannulation relates to its consistent and predictable anatomic location,[1,2] its valve-less course to the superior vena cava, the possibility of repeated cannulation and low incidence of complication in experienced hands. The jugular venous access has a higher incidence of arterial puncture than the subclavian route while the subclavian route has the highest incidence of pneumothorax.[3,4]

Any serious complications including infections of central venous catheter add a substantial amount to the cost of treatment making it a priority to minimize the incidence of any complications. Methods to minimize these complications include choosing an alternate route of central venous access, limiting the number of needles passes, attempt by an experienced operator and use of ultrasound guidance. Catheter-related bloodstream infections are another group of serious complications of central venous catheterization. There is a huge body of evidence demonstrating the safety and efficacy of ultrasound in internal jugular vein cannulation and has prompted the incorporation of ultrasound use in National Institute for Health and Care Excellence (NICE) guidelines for safe practices in 2002.[5–16]

The primary aim of the study was to compare the first attempt success rates of internal jugular vein catheterization by anterior and posterior approach under real-time ultrasound guidance in critically ill patients. Secondary objectives were to compare the following:

- Time taken for identification of internal jugular vein (venous visualization time).
- Time taken for puncturing the vein (venous puncture time).
- Duration of catheterization (catheterization time).
- Complication rates of each approach.

Materials and Methods

Study Design

This prospective randomized study was undertaken in various Intensive Care Units in the Department of Anesthesiology and Critical Care, Dr S.N. Medical College, Jodhpur and Associated Group of Hospitals, after obtaining Institutional Ethical Committee's approval and written informed consent from the critically ill patients' relatives. A total of 90 patients were included in the study who were randomly allocated two groups of 45 each using computer-generated numbers.

- GROUP I- Patients undergoing right internal jugular vein (IJV) cannulation by anterior approach.
- GROUP II- Patients undergoing right IJV cannulation by posterior approach.

Selection of Patients

Inclusion Criteria

- Adult critically ill patients are admitted in various Intensive Care Units under the Department of Anaesthesia and Critical Care of this college.
- Both males and females.
- Aged between 18 and 80 years.
- Requiring central venous catheterization for various reasons.

Exclusion Criteria

Lack of consent, superior vena cava syndrome, infection at the site of cannulation, coagulopathies/patient on heparin or warfarin, presence of carotid disease, contralateral diaphragmatic dysfunction, history of neck surgery, thyroid mass, recent cannulation of internal jugular vein, distorted chest anatomy, and pregnant patients.

Pre Procedural Preparation

Patients' detailed history, general physical examination, and systemic examinations were carried out. Basic demographic data were recorded. Acute physiology and chronic health evaluation II (APACHE-II) and sequential organ failure assessment (SOFA) score on the day of catheterization were assessed. Indications of catheterization and approach of IJV insertion were recorded. All the patients were connected with necessary monitoring devices like electrocardiogram (ECG), pulse oximeter and non invasive blood pressure (NIBP) or invasive blood pressure (IBP). The positive and expiratory pressure (PEEP) was withdrawn in patients on mechanical ventilation. All routine investigations like complete hemogram, liver function tests, renal function tests, coagulation profile (including prothrombin international normalized ratio (PT-INR), activated prothrombin time (aPTT), bleeding time, clotting time) chest X-ray, ECG, and viral markers (including HIV, HbsAg, and Hepatitis-C) were checked. Central venous catheter kit, ultrasound machine, emergency drug kit and defibrillator equipment kept ready in case of any mishappening or complication. The patient was placed in a supine position with 20° Trendelenburg tilt to distend the veins and to minimize the chances of accidental air embolism. After proper positioning, cleaning and draping a 7.5 MHz transducer wrapped in the sterile sheath and sterile ultrasonic gel applied was placed at the appropriate site to obtain a 2D image of the vein. Compressibility of the vein and visible pulsations of the artery was observed in all the patients. The Doppler profile across the vessel showing a continuous flow pattern was utilized to differentiate vein from artery whenever required.

Technique

IJV Catheterization through Anterior Approach

After positioning and preparation, the transducer wrapped in sterile cover was **kept on the neck at the level of cricoid cartilage at the apex of Sedillot's triangle formed by two heads of sternocleidomastoid and clavicle, perpendicular to the skin** to obtain the image of the carotid artery and internal jugular vein in short axis on the screen, with a jugular vein in the center.

IJV Catheterization through Posterior Approach

After positioning and preparation, transducer wrapped in sterile cover was **kept on the neck at the level where external jugular vein crosses the posterolateral border of** sternocleidomastoid muscle.

Parameters Observed

Procedural Parameters

- Number of attempts to identify the vein whether single or multiple (two or more). More than two attempts were taken as a failure and further catheterization was carried out through another approach.
- Venous visualization time: Defined as the time taken from the placement of the USG probe over the skin to the time where a clear image of the internal jugular vein was visualized on the display screen of the USG machine.
- Venous puncture time: Duration of time between the initial skin puncture to the aspiration of dark red venous blood from the internal jugular vein.
- Catheterization time: Time taken from the beginning of aspiration of blood through the needle to the time till successful aspiration of blood from the catheter not including the suturing and fixation time.
- Immediate mechanical complications like carotid artery puncture and subsequent hematoma formation.

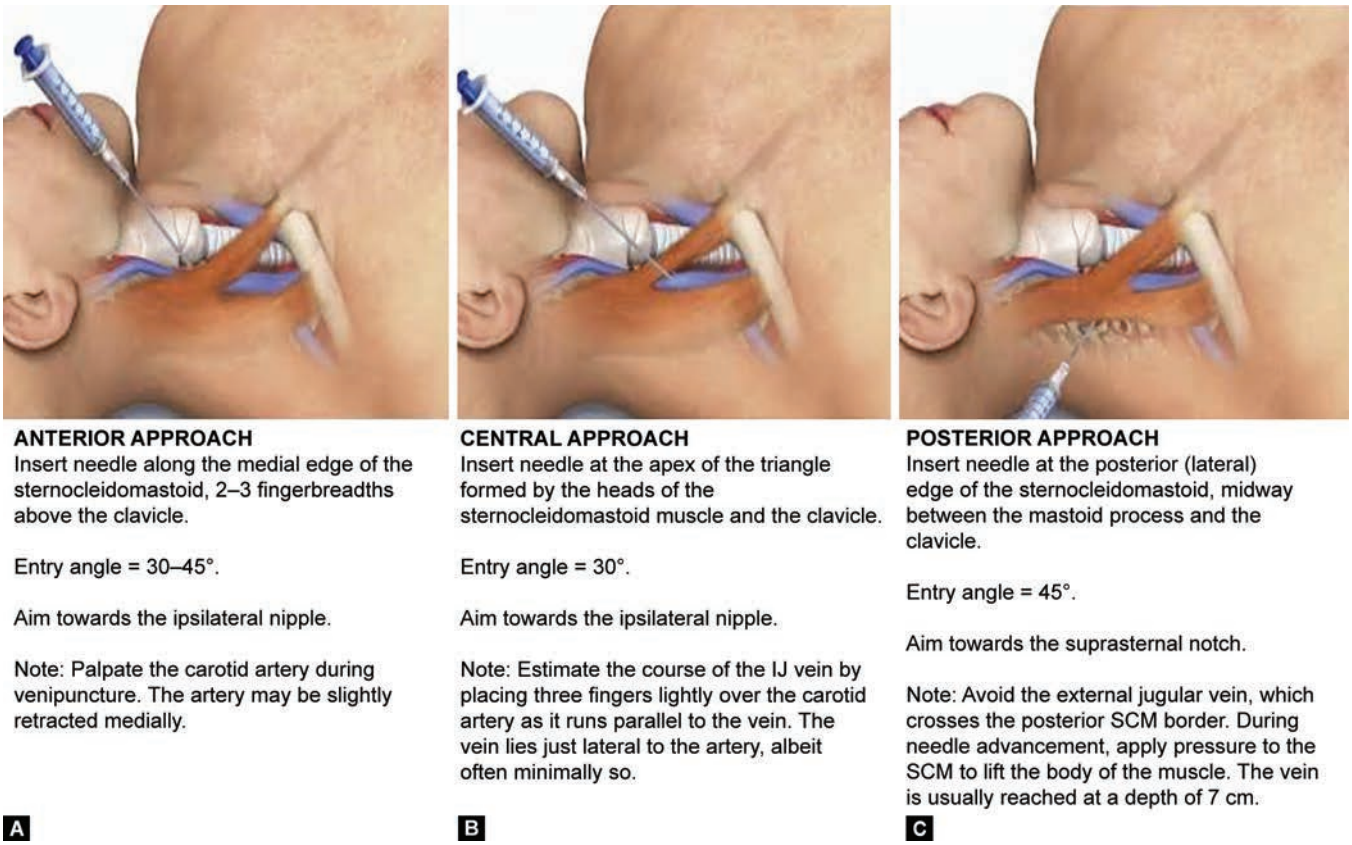
Postprocedural Parameters

- Pneumothorax.
- Hemothorax.
- Catheter displacement.

Statistical Analysis

The sample size of 44 per group was determined by power analysis; according to the preliminary study results of patients of internal jugular venous catheterization, anterior approach vs posterior approach compared with a number of attempts in group I (anterior) 52% vs group II (posterior) 80%, with 80% power and $\alpha = 0.05$.

Randomization was done by using computer-generated numbers. All statistical analysis were performed by using SPSS version 22.0 software package. *t*-test for independent samples was used to compare two groups for data with normal distribution and the Mann-Whitney *U* test was used for comparing data with non-normal distribution. Yates continuity correction test, Chi-square test, Fisher's exact test, and Fisher-Freeman-Halton test were used for comparison of qualitative data. All the data were summarized as Mean ± SD for continuous variables and as numbers and percentages for categorical variables. A *p*-value less than 0.05 was accepted as statistically significant (Figs 1 to 7).



Figs 1A to C: Different approaches to Internal Jugular Vein cannulation

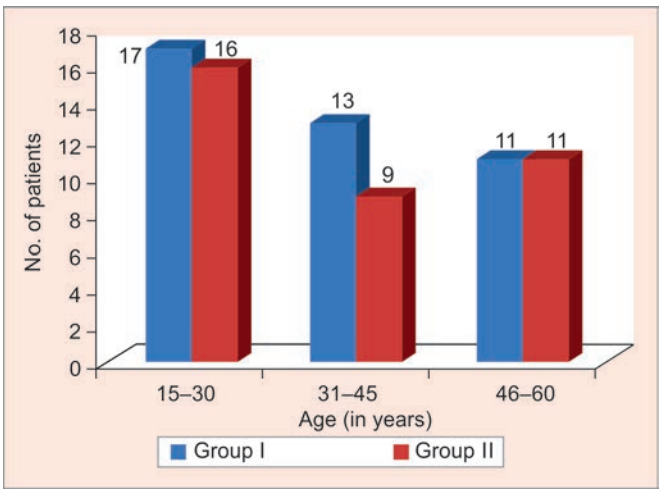


Fig. 2: Distribution of patients based on age

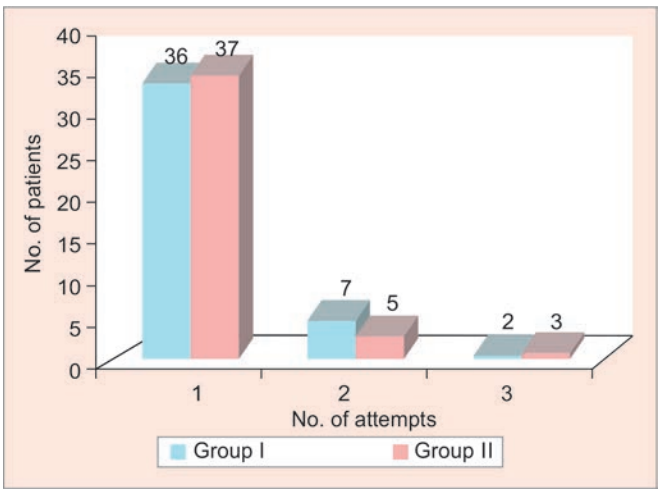


Fig. 5: Comparison of number of attempts taken to cannulate internal jugular vein between two groups

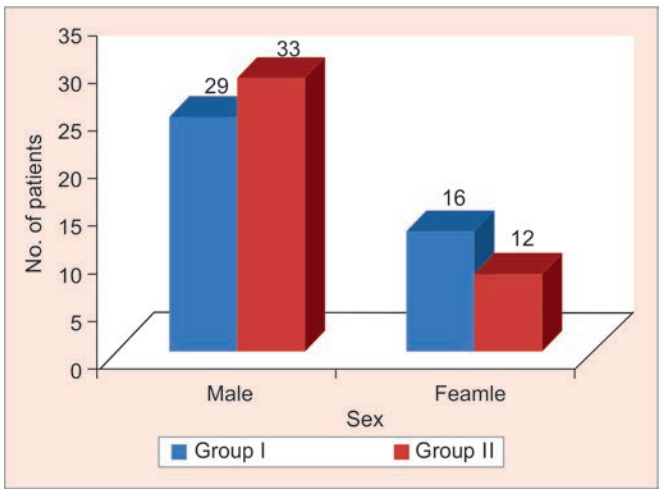


Fig. 3: Distribution of patients based on sex

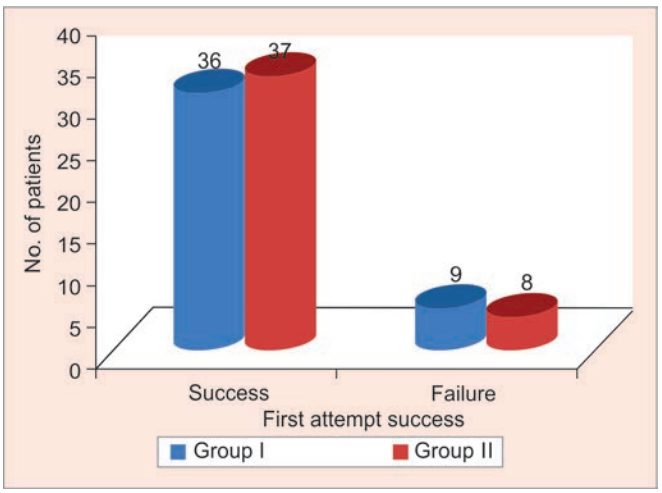


Fig. 6: Comparison of first attempt success rates between two groups

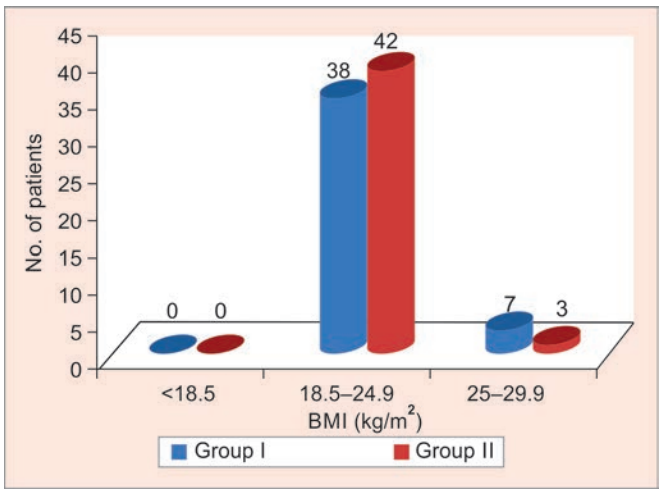


Fig. 4: Distribution of patients according to BMI

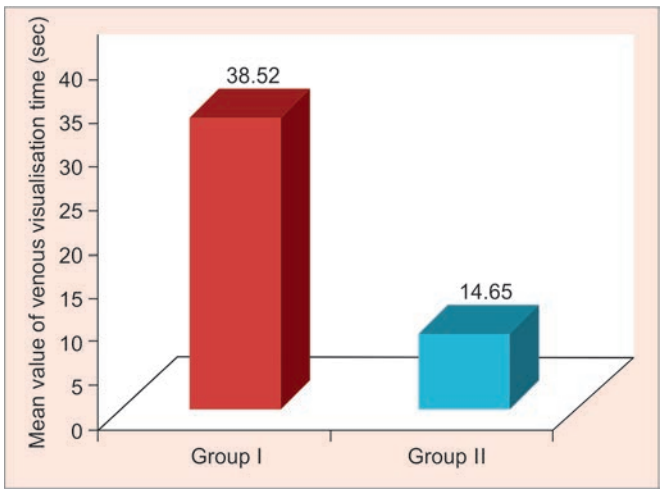


Fig. 7: Venous visualization time in group I and group II

Observationand Results

The following observations were made on the basis of study of patients in two groups admitted and managed in the ICUs headed by the Department of Anaesthesiology at Dr S.N. Medical College, and Associated Group of Hospitals, Jodhpur from June to September 2018. Data so collected was tabulated in an Excel sheet, under the guidance of statistician. Data was analyzed using IBM

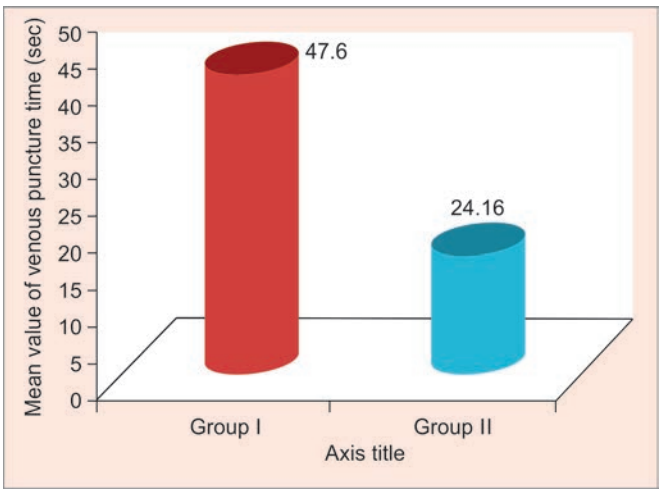


Fig. 8: Venous puncture time in group I and group II

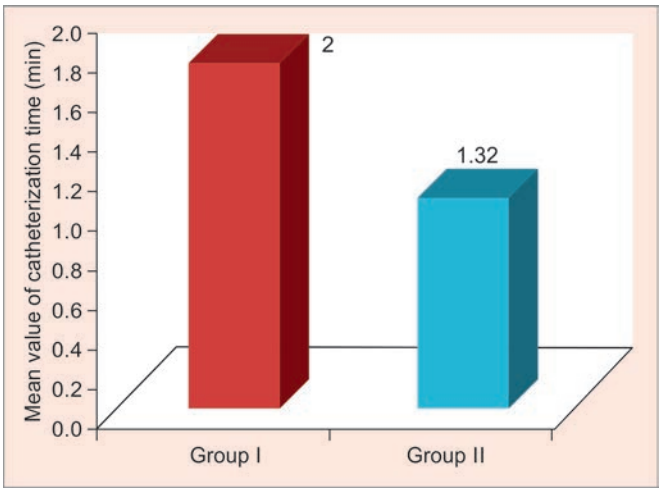


Fig. 9: Catheterization time in group I and group II

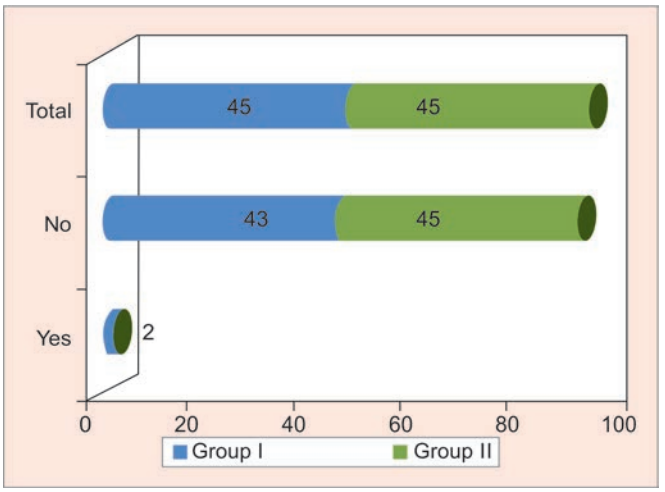


Fig. 10: Incidence of carotid artery puncture between two groups

SPSS Statistics Windows, version 22.0. The statistically significant differences between the groups were determined by the unpaired *t*-test and Fisher's exact test. The level of significance was set at *p*-value less than 0.05 (Figs 1 to 10).

Table 1: Distribution of patients based on age

Age (in years)	*Group I (N = 45)*		*Group II (N = 45)*		
	N	*%*	*N*	*%*	*Total*
15–30	17	37.78	16	35.56	33
31–45	13	28.89	9	20.00	22
46–60	11	24.44	11	24.44	22
>60	4	8.89	9	20.00	13
Mean ± SD	39.8 ± 15.38		43.88 ± 19.09		

p-value 0.266 (NS)

Table 2: Distribution of patients according to sex

Sex	*Group I*		*Group II*		*Total*
	N	*%*	*N*	*%*	
Male	29	64.44	33	73.33	62
Female	16	35.56	12	26.67	28
Total	45	100.00	45	100.00	90

p-value 0.495 (NS)

Table 3: Distribution of patients according to BMI (kg per sq m)

BMI (kg/m^2)	*Group I*		*Group II*		*Total*
	N	*%*	*N*	*%*	
<18.5	0	0.00	0	0.00	0
18.5–24.9	38	84.44	42	93.33	80
25–29.9	7	15.56	3	6.67	10
Mean ± SD	23.29 ± 1.78		23.46 ± 1.18		

p-value 0.597 (NS)

Table 4: Comparison of number of attempts taken to cannulate the internal jugular vein *via* anterior and posterior approach

No. of attempts	*Group I*		*Group II*		*Total*
	N	*%*	*N*	*%*	
First	36	80.00	37	82.22	73
Second	7	15.56	5	11.11	12
Third	2	4.44	3	6.67	5
Total	45	100.00	45	100.00	90

Table 5: Comparison of first attempt success rates between two groups

First attempt success	*Group I*		*Group II*	
	N	*%*	*N*	*%*
Success	36	80.00	37	82.22
Failure	9	20.00	8	17.78
Total	45	100.00	45	100.00

p-value 1.000 (NS)

Table 1 shows the age distribution between the two groups. Unpaired *t*-test was performed on the above data and a *p*-value less than 0.05 was taken as significant. the mean age group of group I was 39.8 ± 15.38 years and in group II was 43.88 ± 19.09 years. The *p*-value between the groups was >0.05 which is statistically insignificant.

Table 2 shows the distribution of patients according to sex. On statistical evaluation by Fischer's exact test, the distribution of sex was found to be comparable between two groups.

Table 3 shows the body mass index (BMI) distribution between two groups. using unpaired *t*-test it was found that there was no statistically significant difference between BMI of two groups. The mean BMI was 23.29 ± 1.78 in group I and 23.46 ± 1.18 in group II. *p*-value was found to be >0.05 which was statistically insignificant.

Table 4 shows number of attempts taken to cannulate internal jugular vein in both the groups which was found to be quite comparable.

Table 5 shows that the first attempt success rate was 80% in group I and 82.22% in group II. *p*-value was found to be more than 0.05 which was statistically insignificant.

Table 6 shows the venous visualization time of two groups compared using unpaired *t*-test and taking a *p*-value less than 0.05 as statistically significant. The mean venous visualization time was 38.52 ± 4.33 seconds in group I and in group II it was 14.65 ± 2.21 seconds. The *p*-value came out to be <0.001 in our study which means that the venous visualization time was lower in group II when compared to group I with statistical significance.

Table 7 shows comparison of venous puncture time between two groups using unpaired *t*-test and taking a *p*-value < 0.05 as statistically significant. The mean venous puncture time in group I was 47.6 ± 4.79 seconds and in group II it was 24.16 ± 2.55 seconds. The results were statistically significant as the *p*-value obtained was less than 0.001.

Table 8 shows the comparison of catheterization time between two groups using unpaired *t*-test and taking a *p*-value < 0.05 as statistically significant. The mean catheterization time in group I was 2.0 ± 0.17 minutes and in group II was 1.32 ± 0.07 minutes. The results were found to be statistically significant as the *p*-value was <0.001.

Table 9 shows the incidence of carotid artery puncture between two groups. in group I puncture was encountered in two patients and in group II there was no incidence of arterial puncture.

Table 6: Comparison of venous visualization time between two groups

Venous visualization time (sec)	*Group I*	*Group II*	*p-value*
Median	38	15	<0.001
Range	30–48	10–18	
Mean ± SD	38.52 ± 4.33	14.65 ± 2.21	

Table 7: Comparison of venous puncture time between two groups

Venous puncture time (sec)	*Group I*	*Group II*	*p-value*
Median	47	25	<0.001
Range	36–56	17–29	
Mean ± SD	47.6 ± 4.79	24.16 ± 2.55	

Table 8: Comparison of catheterization time between two groups

Catheterization time (min)	*Group I*	*Group II*	*p-value*
Median	2.04	1.33	<0.001
Range	1.68 ± 2.30	1.19 ± 1.44	
Mean ± SD	2.0 ± 0.17	1.32 ± 0.07	

Table 9: Incidence of carotid artery puncture between two groups

Carotid artery puncture	*Group I (n = 45)*	*Group II (n = 45)*
Yes	2	..
No	43	45
Total	45	45

Discussion

Internal jugular vein cannulation can be performed by one of the numerous approaches, but the success depends on anatomical variations and operator experience. The purpose of this study was to evaluate a route that would be safer and more efficient than the widely practiced anterior/central approach to IJV cannulation. Since many studies[19,21,24,27,28,31,35] have shown the posterior approach to be better in terms of various procedural parameters and success rates, we selected it for comparison with the anterior approach. We evaluated the success rates, venous visualization, venous access, catheterization times and complications in the two approaches of IJV cannulation. Ultrasound guidance has consistently been shown to improve success rates and minimize complications in central venous access by various routes.[6,20] Various international guidelines[5] also advocate the use of USG guidance for these procedures. Therefore, we decided to include USG guidance as a part of the study protocol.

There were no statistically significant differences in the two groups included in this study in terms of various demographic parameters (age, gender, and BMI). The mean age group of patients in group I was 39.8 ± 15.38 years and in group II was 43.88 ± 19.09 years with *p*-value being 0.266 (nonsignificant). The difference between the two groups on the basis of gender was also nonsignificant with the *p*-value being 0.495. The mean BMI of patients in group I was 23.29 ± 1.78 and in group II was 23.46 ± 1.18 with the *p*-value being 0.597 (nonsignificant). *p*-value of less than 0.05 was accepted as statistically significant in this study.[21–24]

First Attempt Success Rate

In group, I 80% of patients were cannulated in first attempt quite comparable to group II in whom 82.2% of patients were cannulated in first attempt. Results correlated with other studies. In the study conducted by Chowdhary et al.[9] 58% of patients were cannulated in first attempt by anterior approach and 80% of patients were cannulated in first attempt by posterior approach. Mohan Chandralekha V, Darlong V, Kashyap L, et al.[10] observed in their study that successful cannulation rate with few attempts was more in posterior approach (93.8%) than in conventional anterior approach (87.5%). Babu et al.[18] found that the number of attempts required to successfully cannulate in the first attempt was 80% by posterior approach as against 52% by anterior approach. In our study, no statistical significant difference was found in between both the groups in first attempt success rate under real time ultrasound guidance which can be attributed to easier, more accurate identification, and localization of vein using USG leading to comparable results regardless of the approach.

Venous Visualization Time

In our study the average time taken to visualize the vein (time taken from the placement of USG probe over the skin to the time where a clear image of the internal jugular vein was visualized on the display screen of the USG machine) was 38.52 seconds in the anterior

group and 14.65 seconds in the posterior group. The results were highly statistically significant with *p* value being <0.001. Our study results correlate with other relevant studies undertaken till now in which a lesser time was needed to identify the vein in posterior approach.[9,10,22] In the study conducted by Denys et al.[7] average access time (skin to vein) was also significantly shorter with ultrasound approach (9.8 sec) when compared to landmark approach (44.5 seconds) ($p < 0.001$). Chowdhary et al.[9] in their study concluded that the access time to vein was significantly lower with posterior approach when compared to anterior approach. They did both the approaches with landmark identification though. Babu et al.[18] found that the time required to identify the vein was significantly less with posterior approach with a mean value of 0.18 min, compared to 1.06 min with anterior approach. The possible reason for these findings could be due to rapid identification of vein in posterior approach because of greater cross-sectional area and easier differentiation from surrounding structures.

Venous Puncture Time

The average venous puncture time (duration of time starting from the initial skin puncture to the aspiration of dark red venous blood from the internal jugular vein) in our study was found to be significantly lower in the posterior group than the anterior one ($p < 0.001$) being 24.16 seconds in posterior and 47.60 seconds in the anterior group. Our results correlated well with other studies. Mohan Chandralekha et al.[10] have compared posterior approach with central approach and showed posterior to be better in terms of venous access time and venous puncture time. Manjula BP, Deepthi HV[21] in their study had similar results. This difference can be explained on the basis of superior visualization of the vein in posterior approach and thus a more confident and accurate puncture.

Catheterization Time

In our study the mean duration of catheterization (time taken from the beginning of aspiration of blood through the needle to the time till successful aspiration of blood from all the three ports of catheter inserted up to 12–13 cm in the vein not including the suturing and fixation time) in anterior group was 2 minutes and in posterior group was 1 minute 32 seconds. The results were highly statistically significant ($p < 0.001$). The catheterization time has been reported to be shorter in posterior approach than the anterior approach.[9,15,21] Manjula and Deepthi et al.[21] concluded that posterior approach is easier to cannulate as compared to anterior in terms of number of attempts, duration of cannulation. Lamkinsi et al.[15] showed similar results. The possible reason for less time consumption in the ultrasound guided posterior approach could be the greater cross-sectional area of the vein in posterior approach than the anterior approach with the patient being in Trendelenburg's position.[22] A larger cross-sectional area permits earlier identification of vein, easy, and speedy threading of the catheter. Hence the time required for cannulation is reduced in posterior approach.

Complication Rates

In our study the incidence of carotid puncture was found to be higher in anterior group (2 out of 45 patients) and NIL in posterior approach under real time ultrasound guidance. Mohan Chandralekha V, Darlong V, Kashyap L et al.[10] noted that the incidence of carotid arterial puncture was less with posterior approach (7 out of 80 patients) as compared to central approach (18 out of 80 patients) in their study. In another study by Chowdhary et al.[9] the overall incidence of carotid puncture was high in anterior approach (5%) than the posterior approach (2%). Sindhu et al.[11] in their study concluded that IJV cannulation is a simple and safe means of access to a central vein both for elective procedures and in an emergency. Moreover, with posterior approach the incidence of complications such as carotid puncture is less. Babu et al.[18] in their study found similar results. Manjula and Deepthi et al.[21] also revealed similar results with posterior approach. The reason attributed to this could be anatomic variations of internal jugular vein in relation to carotid artery permitting lesser chances of arterial puncture with posterior approach as per a study conducted by Chandrasekharan and Chandrasekharan et al.[14] Moreover we cannulated the vein under USG guidance in this study which has been proven to reduce the incidence of carotid arterial punctures and subsequent hematoma formation.[7–24]

In the two cases of carotid puncture needle was withdrawn immediately and firm compression was applied. Then further the vein was cannulated again on the same side after about 2 hours. No incidence of hematoma formation was noted in our study.

There were no incidence of pneumothorax and hemothorax noted in our study. As the needle punctures were made under USG guidance, it could be the reason for increased accuracy of punctures and nil incidences of pneumothorax and hemothorax. Tammam et al.[16] in his study suggested that USG-guided techniques were superior to the landmark technique for insertion of CVCs as the complication rates were significantly lower with USG.

The efficacy of USG in reducing the incidences of various immediate and delayed complications even in the hands of an inexperienced operator was demonstrated in a study conducted by K Rando, J Castelli.[17] They emphasized the necessity of ultrasound in the centers with residents as in their study they noted fewer complications (7.8% vs 24%) in the "nonexpert" group with the use of ultrasound.

Moreover, the incidences of catheter displacement (migration of the catheter to the ventricle or to the extra-thoracic site) in our study were noted 3 out of 45 cases in anterior group and 1 out of 45 cases in posterior group. The results were statistically insignificant. However, in one study conducted by Song et al.[19] it was recommended that skin puncture site in the neck at the posterior triangle is better than the sedillot's triangle and using this approach, the possible complications of pinching and kinking of the catheter can be reduced. Pikwer et al.[22] has observed that the rate of catheter malposition was 3.3% in the anterior approach compared with 1% in the posterior approach. The reason attributed to catheter displacement is improper suturing leading to catheter slipping during neck movements. Proper suturing and fixation avoid it.[19]

Limitation of the Study

Firstly, it did not take into account the pediatric age group, obese patients, pregnant females and patients having short neck or any kind of thyroid mass. *Secondly,* this study has not statistically analyzed the number of attempts, venous access time and duration of catheterization and immediate complication rates in short neck and obese patients included in the study. *Thirdly,* long-axis approach was not used at any point while making needle punctures and guidewire advancement. And *lastly,* the critically ill patients included in the study were not categorized further according to their primary diagnosis and comorbidities such as patients in severe shock on vasopressor support or patients with cardiac failure or patients with bleeding diathesis which could affect the success rates of catheterization, ease of identifying the vein, catheterization time,

and incidence of complications. Small sample size and a non-blinded assessment of outcomes were the *other drawbacks* of this study.

Conclusion

Thus to sum up, though the Anterior approach is being practiced more widely and frequently for percutaneous internal jugular vein catheterization under real-time ultra-sonographic guidance in critically ill patients admitted in ICUs but the posterior approach has been noted to be better in terms of accuracy, access time, duration of catheterization and complication rates in this study and could be a safer alternative in terms of ease and speed of catheterization in patients who are already having increased morbidity.

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