Comparison Of Anterior And Posterior Approach Of Percutaneous Catheterization Of Internal Jugular Vein Under Real Time Ultrasound Guidance In Critically Ill Patients: A Prospective Randomised Study

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Abstract: Background: Central venous catheterization is a vital intervention in critically ill patients. The purpose of this study was to compare the procedural parameters and complications associated with anterior and posterior approaches of IJV catheterization under real time ultrasound guidance in critically ill patients. Material And Methods: In this prospective randomised study, 90 patients admitted in various ICUs were randomly allocated two groups of 45 each, including both males and females aged between 18 to 80 years of age requiring central venous catheterization for various indications. Result: The first attempt success rates were comparable between both the groups. The venous visualization time was 38.52 seconds in Group A and 14.65 seconds in Group P ($p<0.001$). The venous puncture time and the duration of catheterization was found to be 47.60 sec & 2 minutes in Group A respectively and 24.16 sec & 1 minute 32 sec in Group P respectively ($p<0.001$). No statistically significant differences were found between the two groups in terms of incidence of carotid arterial puncture, haematoma formation and catheter displacement. Conclusion: It was observed that the posterior approach is better than anterior approach of USG guided IJV catheterization as it improves the accuracy, reduces the access time and duration of catheterization & leads to fewer incidences of immediate complications like carotid arterial puncture & subsequent haematoma formation. [M T Natl J Integr Res Med, 2021; 12(5): 62-72]

Key Words: Internal Jugular Vein Cannulation, Anterior Approach, Posterior Approach, Ultrasound, Critically Ill Patients

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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 & 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 contra-indications, risk of complications, patient factors predicting difficult cannulation and the clinical conditions. The proper choice of insertion is essential for success. Advantage of internal jugular vein cannulation relates to its consistent & 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 subclavian route while the subclavian route has the highest incidence of pneumothorax[3,4]. Any serious complications including infections of central venous catheter adds 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 alternate route of central venous access, limiting the number of needle passes, attempt by an experienced operator and use of ultrasound guidance. Catheter related blood stream 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 NICE guidelines for safe practices in 2002[5].

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.

Material & Methods: Study Design: This prospective randomized study was undertaken in various Intensive Care Units under the Department of Anaesthesiology & Critical Care in 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 that were randomly allocated two groups of 45 each using computer generated numbers. Group A: Patients undergoing right IJV cannulation by Anterior approach. Group P: Patients undergoing right IJV cannulation by Posterior approach.

Selection Of Patients: Inclusion Criteria: Adult critically ill patients admitted in various Intensive Care Units under the Department of Anaesthesia & Critical Care of this college. Both males and females. Aged between 18 to 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, contra-lateral diaphragmatic dysfunction, history of neck surgery, thyroid mass, recent cannulation of internal jugular vein, distorted chest anatomy & pregnant patients.

Pre Procedural Preparation: Patients' detailed history, general physical examination, systemic examinations were carried out. Basic demographic data were recorded. APACHE-II and 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 ECG, Pulse Oximeter and NIBP or IBP. The PEEP was withdrawn in patients on mechanical ventilation. All routine investigations like complete haemogram, liver function tests, renal function tests, coagulation profile (including PT-INR, aPTT, bleeding time, clotting time) chest X- Ray, ECG & viral markers (including HIV, HbsAg, 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 supine position with 20 degree trendelenberg 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 sterile sheath and sterile ultrasonic gel applied was placed at appropriate site to obtain a 2D image of the vein.

Compressibility of the vein and visible pulsations of the artery were 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, 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 carotid artery and internal jugular vein in short axis on the screen, with jugular vein in the centre.

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 (2 or more). More than two attempts were taken as a failure and further catheterization was carried out through other 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 visualised 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 haematoma formation.

Post-Procedural Parameters: Pneumothorax, Haemothorax, and 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 versus Posterior approach compared with number of attempts in Group 1 [Anterior] 52% V/s Group 2 [Posterior] 80%, with 80% power and $\alpha = 0.05$.

Randomisation was done by using computer generated numbers. All statistical analysis was 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 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 was used for comparison of qualitative data. All the data were summarised as Mean ± SD for continuous variables and as numbers & percentages for categorical variables. A p value less than 0.05 was accepted as statistically significant.

Results: The following observations were made on the basis of study of patients in two groups admitted and managed in the ICUs headed by Department of Anaesthesiology & Critical Care 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 SPSS Statistics Windows, version 22.0. The statistically significant differences between the groups were determined by the unpaired t-test & Fisher's exact test. The level of significance was set at P-value less than 0.05.

Table 1: The Age Distribution Between The Two Groups

Age (In Years)	Group A (N=45)		Group P (N=45)		Total
	N	%	N	%	
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**		

Table No.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**. P-value 0.266 (NS)**

Figure 1: Distribution Of Patients Based On Age

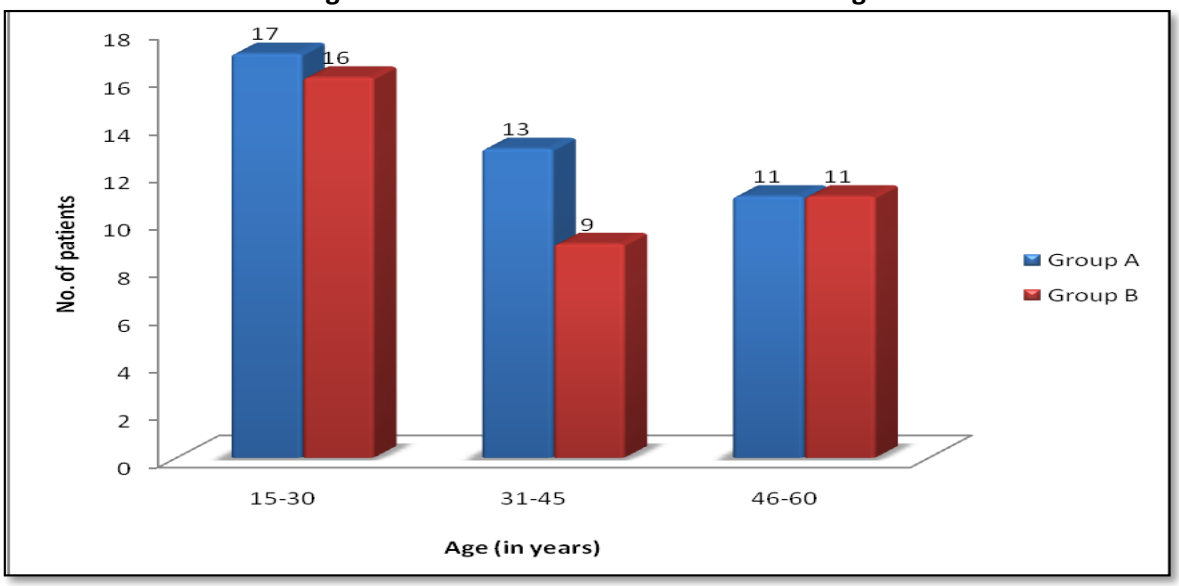


Table 2: The Distribution Of Patients According To Sex

Sex	Group A		Group P		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

Table No.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. P-value 0.495 (NS).

Figure 2: The Distribution Of Patients Based On Sex

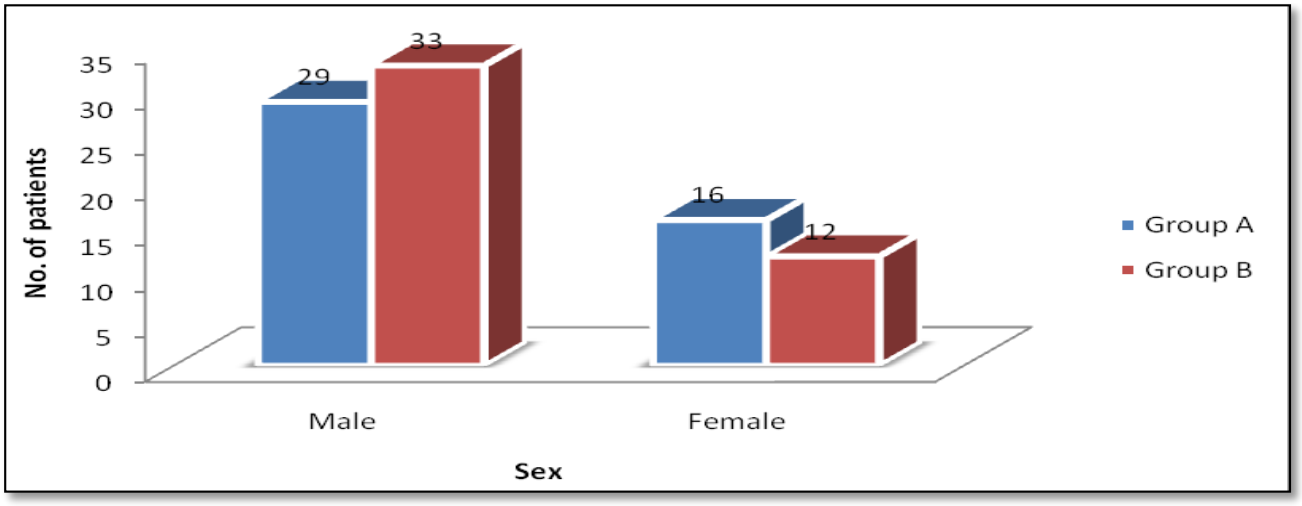


Table 3: The BMI Distribution Between Two Groups

BMI (kg/m2)	Group A		Group P		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**		

Table no.3 shows the BMI distribution between two groups. Using unpaired t-test it was found that there was no statistically significant difference between BMI of two groups. P-value 0.597 (NS).

Figure 3: Distribution of patients according to BMI

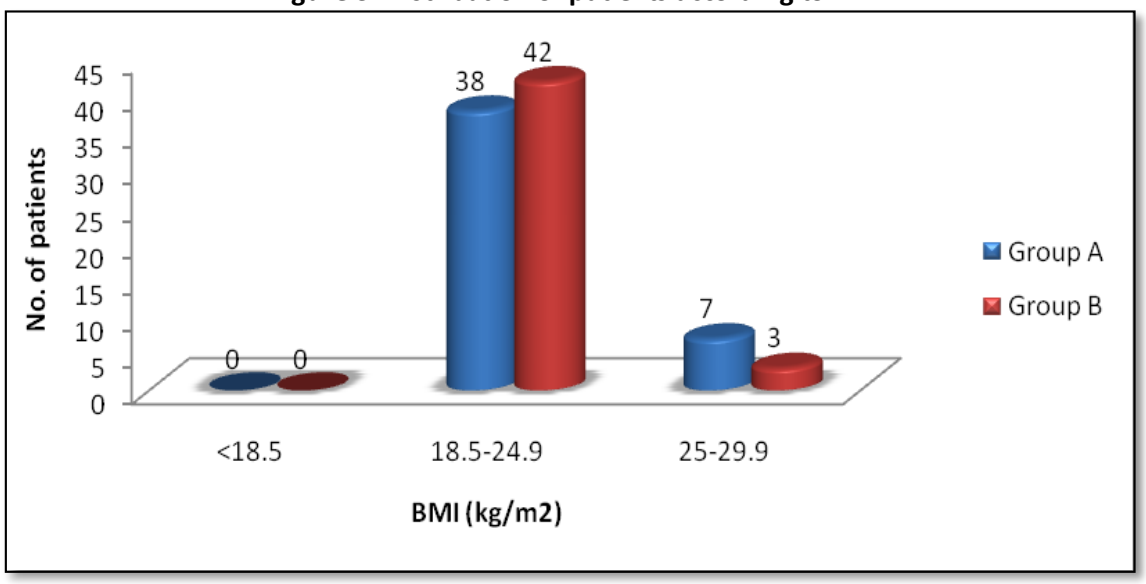


Table 4: Number Of Attempts Taken To Cannulate Internal Jugular Vein In Both The Groups

No. Of Attempts	Group A		Group P		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 no. 4 shows number of attempts taken to cannulate internal jugular vein in both the groups which was found to be quite comparable.

Figure 4: Comparison Of Number Of Attempts Taken To Cannulate Internal Jugular Vein Between Groups

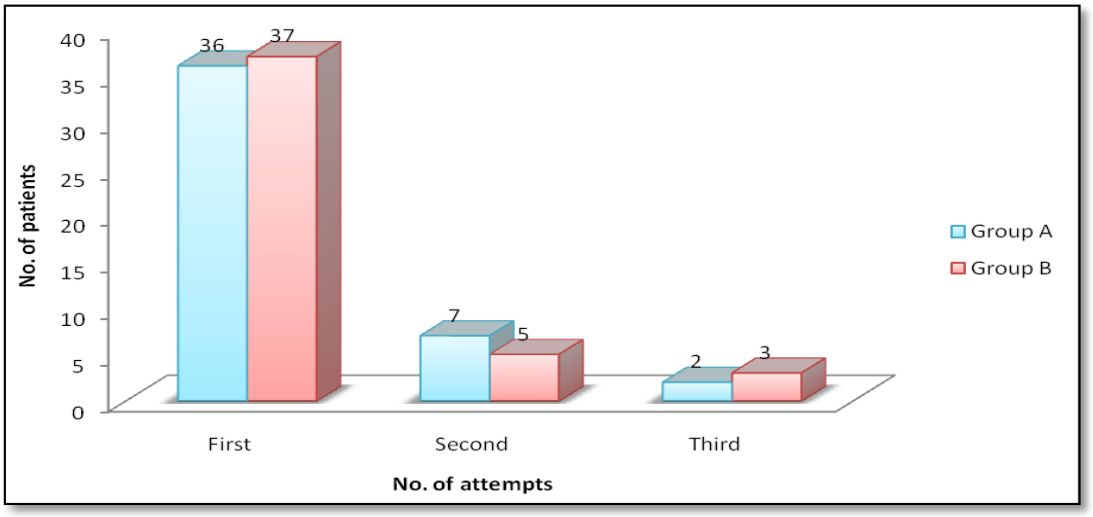


Table 5: Comparison Of First Attempt Success Rates Between Two Groups

First Attempt Success	Group A		Group P	
	N	%	N	%
Success	36	80.00	37	82.22
Failure	9	20.00	8	17.78
Total	45	100.00	45	100.00

Table no. 5 shows that the first attempt success rate was 80% in Group A & 82.22% in Group P. P-value 1.000 (NS).

Figure 5: Comparison Of First Attempt Success Rates Between Two Groups

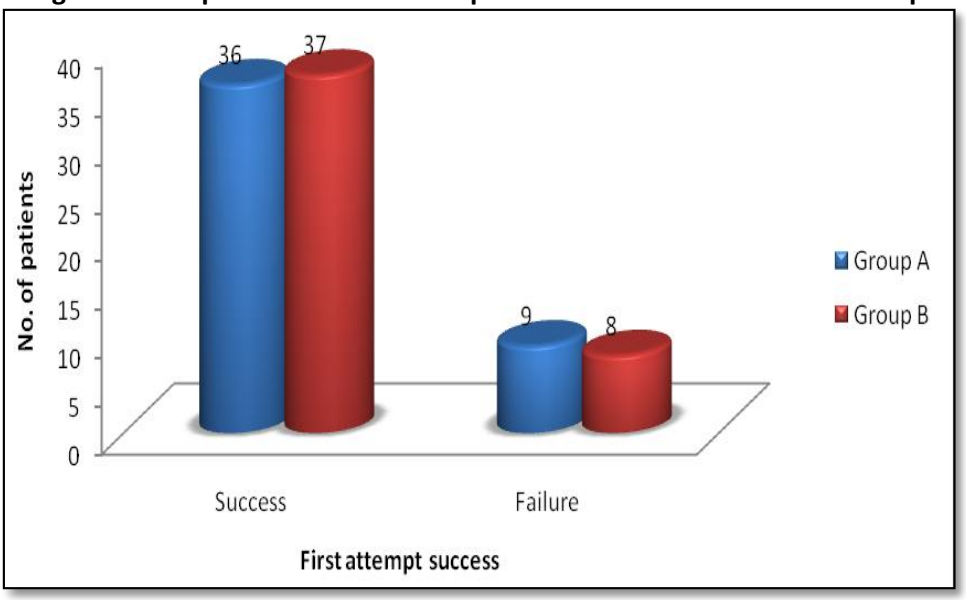


Table 6: Venous Visualization Time In Group A & Group P

Venous Visualization Time (Sec)	Group A	Group P	P value
Median	38	15	<0.001
Range	30-48	10-18	
Mean±SD	38.52±4.33	14.65±2.21	

Table No.6 shows the venous visualization time of two groups compared using unpaired t-test. P-value came out to be < 0.001 in our study which means that the venous visualization time was lower in Group P when compared to Group A with statistical significance.

Figure 6: Venous Visualization Time In Group A & Group P

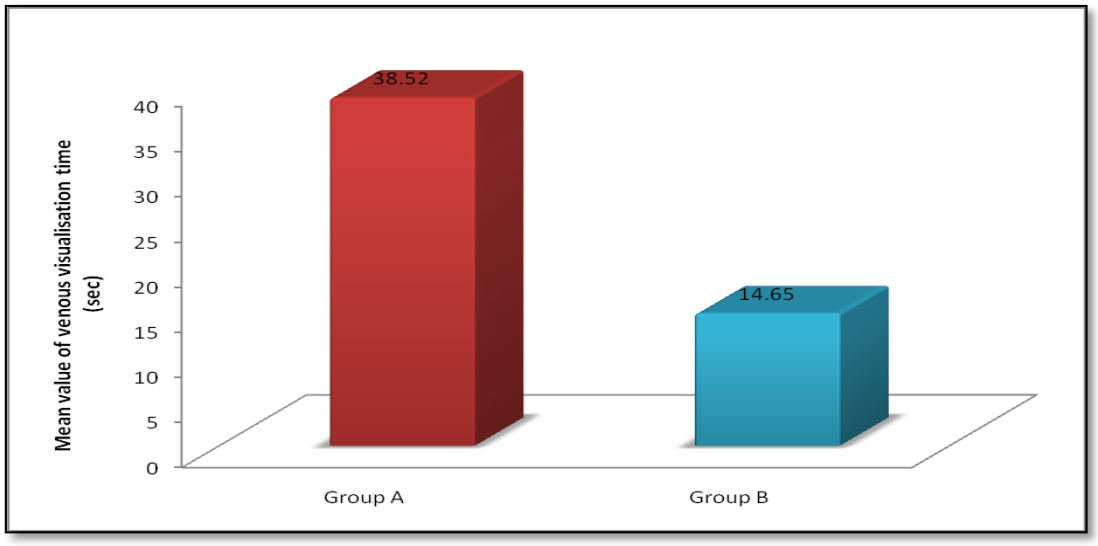


Table 7: Comparison Of Venous Puncture Time Between Two Groups Using Unpaired T-Test

Venous Puncture Time (Sec)	Group A	Group P	P Value
Median	47	25	<0.001
Range	36-56	17-29	
Mean ± SD	47.6±4.79	24.16±2.55	

Table No.7 shows comparison of venous puncture time between two groups using unpaired t-test. The results were statistically significant as the P-value obtained was less than 0.001.

Figure 7: Venous Puncture Time in Group A & Group P

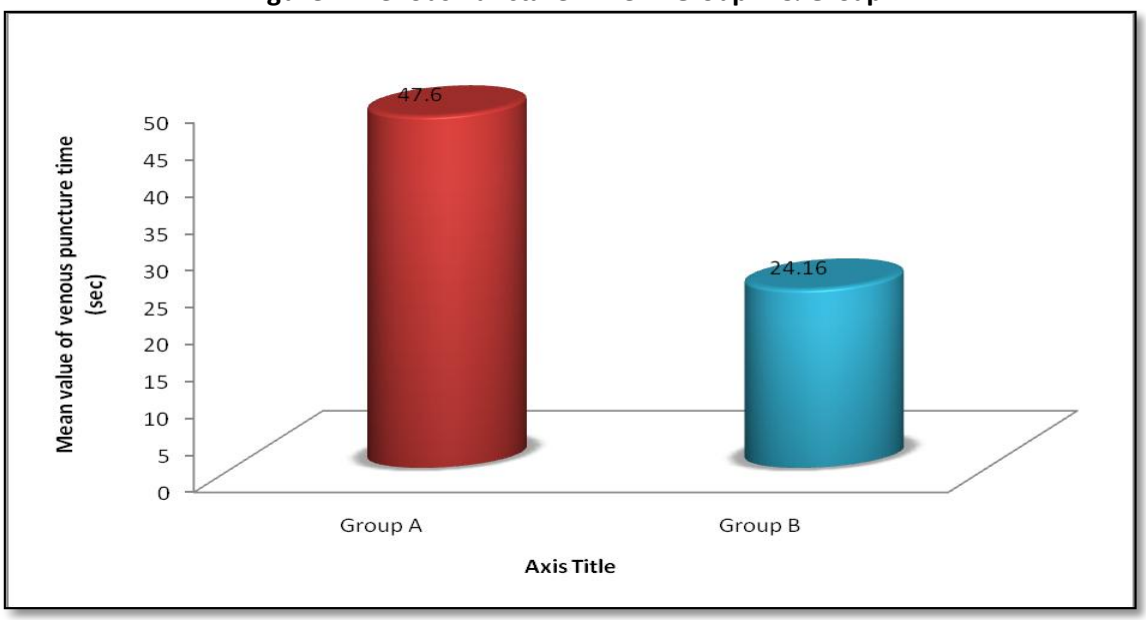


Table 8: The Comparison Of Catheterization Time Between Two Groups Using Unpaired T-Test

Catheterization Time (Min)	Group A	Group P	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 No. 8 shows the comparison of catheterization time between two groups using unpaired t-test. The results were found to be statistically significant as the P-value was <0.001.

Figure 8: Catheterization Time In Group A & Group P

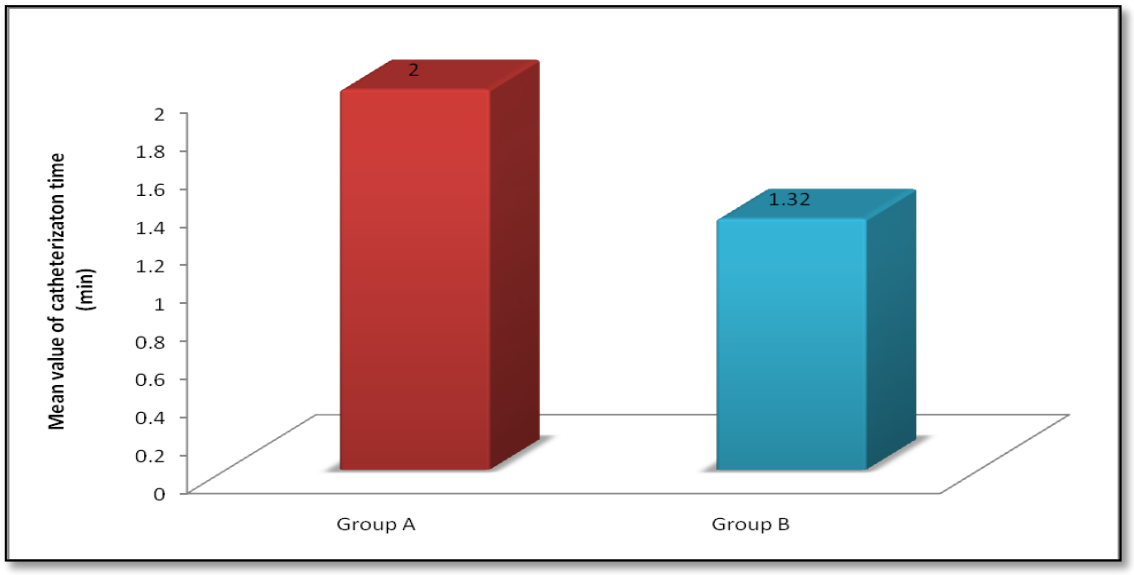
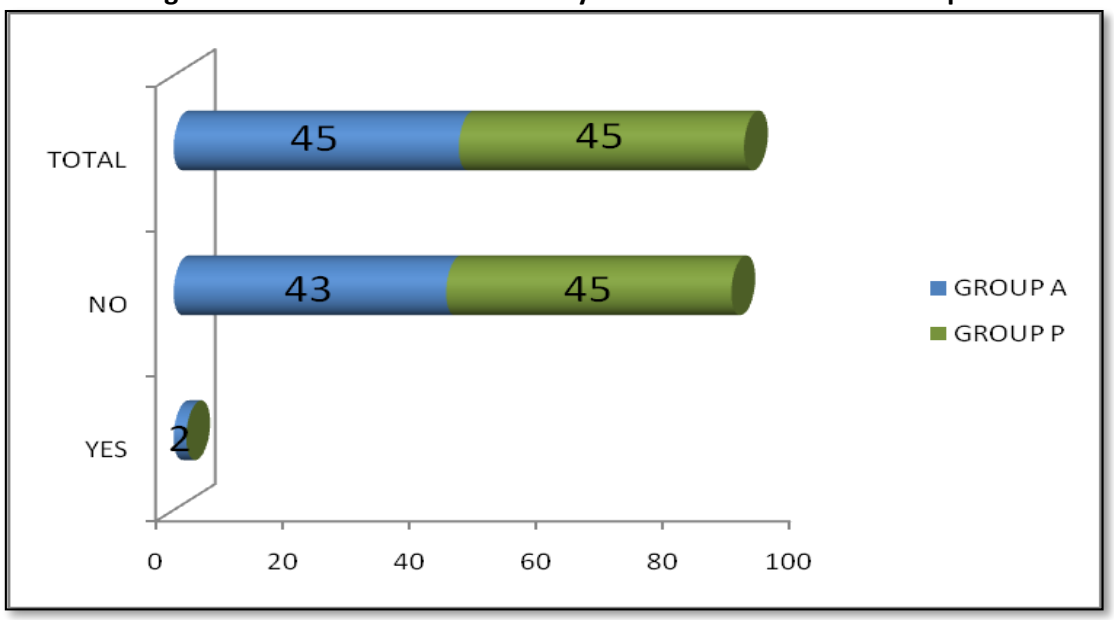


Table 9: The Incidence Of Carotid Artery Puncture Between Two Groups

Carotid Artery Puncture	Group A (N=45)	Group P (N=45)
Yes	2	0
No	43	45
Total	45	45

Table No.9 shows the incidence of carotid artery puncture between two groups. In Group A puncture was encountered in 2 patients & in Group P there was no incidence of arterial puncture.

Figure 9: Incidence Of Carotid Artery Puncture Between Two Groups



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 which would be safer & 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 & success rates; we selected it for comparison with anterior approach.

We evaluated the success rates, venous visualization, venous access, catheterization times & 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[6,7,8,12,13,16,17,19,20]. 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 & BMI). The mean age group of patients in group A was 39.8±15.38 years & in group P was a 43.88±19.09 year with P-value being 0.266 (non-significant). The difference between the two groups on the basis of gender was also non-significant with the P-value being 0.495. The mean BMI of patients in group A was 23.29±1.78 & in group P was 23.46±1.18 with the P-value being 0.597 (non-significant). P-value of less than 0.05 was accepted as statistically significant in this study.

First Attempt Success Rate: In Group A 80% of patients were cannulated in first attempt quite comparable to Group P in whom 82.2% of patients were cannulated in first attempt. Results correlated with other studies. In the study conducted by Chowdhari L.S. et al[9] 58% of patients were cannulated in first attempt by anterior approach & 80% of patients were cannulated in first attempt by posterior approach. Mohan Chandralekha V, Darlong V, Kashyap L et al[21] 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%). B Vishnu Mahesh 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 & 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 BG 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). L. S. Kumar chowdhari 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. B Vishnu Mahesh 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 & 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 proach and showed posterior to be better in terms of venous access time & 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 BP 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 trendelenberg's position[22].

A larger cross-sectional area permits earlier identification of vein, easy & 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) & NIL in posterior approach under real time ultrasound guidance. Mohan Chandralekha V, Darlong V, Kashyap L et al[21] 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 L.S, Karmakar U.S, Dixit R.T, Sonia K et al[9] the overall incidence of carotid puncture was high in anterior approach (5%) than the posterior approach (2%). Sindhu S 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. B Vishnu Mahesh Babu et al[18] in their study found similar results. Manjula BP 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 V.P 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 & subsequent haematoma formation[7,10,12,13,16,20,23,24]. In the 2 cases of carotid puncture needle was withdrawn immediately & firm compression was applied. Then further the vein was cannulated again on the same side after about 2 hours. No incidence of haematoma formation was noted in our study.

There were no incidence of pneumothorax and haemothorax 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 haemothorax.

Tammam TF 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 & 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% versus 24%) in the "non expert" group with the use of ultrasound.

Moreover the incidences of catheter displacement (Migration of the catheter to the ventricle or to extra-thoracic site) in our study were noted 3 out of 45 cases in Anterior group & 1 out of 45 cases in Posterior group. The results were statistically insignificant. However in one study conducted by Song D, Yun S 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, A.Baath, L.Davidson, B.Perstoft, I.Ayerson J[22] et al 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 avoids it[19].

Limitation Of The Study: Firstly, it did not take into account the paediatric age group, obese patients, pregnant females and patients having short neck or any kind of thyroid mass. Secondly this study has not statistically analysed the number of attempts, venous access time and duration of catheterization and immediate complication rates in short neck & 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 & co-morbidities 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 & incidence of complications. A small sample size & 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 & 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 & complication rates in this study & 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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