Section: Anaesthesiology

Original Research Article

COMPARATIVE STUDY OF RIGHT INTERNAL JUGULAR VEIN CANNULATION BY THE REAL-TIME ULTRASOUND IMAGING, ULTRASOUND-GUIDED PRELOCATION AND THE ANATOMICAL LANDMARK TECHNIQUE - A PROSPECTIVE RANDOMIZED TRIAL

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Abstract

Background: Central venous catheter placement is frequently performed in emergency medicine and critical care units. We aim to compare real-time ultrasound imaging, ultrasound-guided prelocation and the anatomical landmark technique for right internal jugular vein cannulation. **Materials and Methods:** This prospective randomised observational study was done at Thanjavur medical college and Hospital. 75 patients were divided into three groups, namely anatomical landmark, ultrasound-guided prelocation, and ultrasound-guided real-time imaging groups, each with 25 patients. Parameters like Cannulation success rate, venous access time, catheterization time, number of attempts and complications were observed in each group of patients. **Result:** IJC success rate was reported highest in group USG-RT (96%), followed by group USG-PL (92%) and Group USG-AL (76%). The catheterization attempts were less than three times in group AL (76%), group USG PL (88%) and group USG RT (96%). The success rate of IJV cannulation in a Time interval of < 3 min in group AL was (0%), group USG PL (8%), and group USG RT (4%) with significant effect ($p<0.05$). The success rate of IJV cannulation in a Time interval of < 5 mins in group AL was 13(52%), group USG PL 20 (80%), and group USG RT 22 (88%). Complications like Carotid artery puncture occurred highest in the anatomical landmark with (12%) of patients. **Conclusion:** In the current study, the ultrasound prelocation and the Ultrasound real-time group showed better results when compared to the anatomical landmark group.

INTRODUCTION

Central venous cannulation is a relatively common procedure in many branches of medicine, particularly in anaesthesia and intensive care medicine. Central venous catheterization has specific indications and should be reserved for the patient who has the potential to benefit from it.[1] Historically, central venous access was gained by surgical cut-down procedures. Still, central venous catheters are now inserted percutaneously using a technique first described by Seldinger in 1953.[2] There are many different types of catheters and several different sites suitable for central venous access, with selection depending on numerous factors, including the reason for and duration of access, anatomy of the patient, local resources and operator skill and experience.[3]
Hermosura et al. described right internal jugular cannulation in 1966, and since then, it has become one of the most popular routes for central venous cannulation.[4] The internal jugular vein is the most frequently chosen central venous catheter insertion site. It is a potentially large vein with a lower pneumothorax risk than the subclavian approach puncture. Later many anatomical landmark-guided techniques for internal jugular vein (IJV) cannulation have been described.[5] A high approach reduces the risk of pneumothorax but increases the risk of arterial puncture. For lower approaches, the converse is true. With experience, this route has a low incidence of complications.[6]
Ultrasound-guided internal jugular vein (IJV) cannulation is known for increasing the success rate and decreasing the rate of complications. The ultrasound image can be used as a real-time image during cannulation or to prelocate the IJV before attempting cannulation.[7] Real-time ultrasound-guided imaging has been advocated as it improves the

success rate and reduces the number of attempts and complication rate. However, its widespread use has been restricted by the impracticality of a specially designed ultrasound machine or sterile scanner manipulation, the unavailability of equipment, and trained personnel.[8]

Alternatively, ultrasound imaging can be applied to evaluate anatomic structures before attempting venous puncture. This helps clinicians locate the carotid artery and the IJV and determine the direction and site of venepuncture. However, few prospective studies compare IJV cannulation by real-time ultrasound imaging, ultrasound-guided prelocation, and the anatomical landmark technique (central approach).[9] Hence, the present study compared right internal jugular vein cannulation by real-time ultrasound imaging, Ultrasound-guided prelocation and the anatomical landmark technique.

MATERIALS AND METHODS

This prospective randomised observational study was done at Thanjavur medical college and Hospital. The study was performed on 75 patients admitted for elective surgery requiring IJV cannulation. Institutional ethical committee approval and written informed consent was taken from all subjects before the start of the study.

Inclusion Criteria

Patients of either sex, aged between 15 to 65 years, who were admitted for elective surgery requiring IJV cannulation were included.

Exclusion Criteria

Patients with previous neck surgeries, head and neck mass or cancer, superior vena cava syndrome, local infection at the catheterization site, coagulopathy and emergency cannulation. In addition, patient history of previous cannulation, I/V drug abuse, IJV thrombosis and pregnancy were excluded.

Methodology

Patients were randomly allocated to one of the three groups using closed - envelope method (25 in each group). Patients of the first group had their right IJV catheter inserted by traditional anatomical landmark technique using the central approach (Group AL). The right IJV was prelocated with the help of an ultrasound probe (Group USG-PL) before catheterization. The last group used ultrasound-guided real-time imaging for their right IJV catheter insertion (Group USG-RT).

Standard monitoring (ECG, NIBP, HR and SPO2) were applied to all patients. All patients were positioned in the Trendelenburg (15-30°) position with their heads turned slightly toward the left side and stabilized with folded towels. Anatomical landmarks (sternocleidomastoid muscles, sternal notch, cricoid cartilage, and clavicle) were identified and marked. The right side of the neck region was prepared with a Betadine solution.

In Group AL: An 18G introducer needle attached to a 5ml syringe was inserted at the apex of the triangle formed by the two heads of the sternocleidomastoid muscle, directed toward the ipsilateral nipple at an angle of 15-30° with the skin.

In Group USG-PL (Prelocation) group: The transducer of the ultrasound device was placed at the level of the cricoid cartilage, perpendicular to the skin, on the right side of the neck. Compressibility of the vein and visible pulsations of the artery was used to identify the carotid artery and the IJV. From the transverse cross-sectional view, anatomical dimensions, relative position and distance from the skin of the carotid artery and IJV were noted. The venepuncture site was also determined and marked (Prelocation), and cannulation was performed.

In Group USG-RT: Cannulation was performed under real-time imaging. Return of free-flowing dark venous blood to the syringe attached to the needle confirms entry into the IJV. This was followed by catheterization of the right IJV. The CVP catheter was secured with sutures, and a sterile dressing was applied.

Triple-lumen central venous pressure (CVP) catheter (7°F) was used for catheterization in all patients. A 7.5 MHz transducer (Probe) attached to the 2D image display of the ultrasound machine was used in this study. A sterile polyethylene sheath was used to protect the ultrasound probe and gel. The position of the tip of the CVP catheter and the occurrence of pneumothorax was confirmed by performing a chest radiograph. Complications like artery puncture during the procedure were managed by compression for 3 mins to avoid hematoma formation. Parameters, cannulation success rate, venous access time, catheterization time, number of attempts and complications (Artery puncture, Haematoma etc.) were observed in each group of patients.

Statistical Analysis

Statistical analysis was performed using SPSS 16 software. Demographic data (age, weight, height, body mass index) were compared using one-way analysis of variance (ANOVA), and sex distribution was compared using the Chi-square test. The venous access time and catheterization time were compared using the Kruskall-Wallis test. Successful cannulation, successful catheterization with the number of attempts, the success rate in different time intervals, catheterization time >15 minutes, and complications were compared by applying the Chi-square test and Fisher exact test. A P value of < 0.05 was taken to be statistically significant for all parametric and categorical data in this study.

RESULTS

The demographic parameters like mean age, weight, height, and gender distribution were comparable in all three groups [Table 1].

IJC success rate was reported highest in group USG-RT (96%) followed by group USG-PL (92%) and Group USG-AL (76%), although the effect was statistically insignificant (p=0.071) among all

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groups. The mean venous access time was found to be maximum in the USG-AL group (15.32 sec) and minimum in the USG-PL group (11.16 sec), and the effect was statistically insignificant (p=1) among groups. The mean catheterization time in Group AL was 182.32 sec, Group USG PL was 162.24 sec, and Group USG RT 161.72 sec and was found to be statistically insignificant (p=0.422) between groups. The catheterization attempts were less than three times in group AL was 19 (76%), group USG PL was 22 (88%), and group USG RT at 24 (96%), and it was statistically not significant(p=0.106) at all three groups [Table 2].

The success rate of IJV cannulation in Time intervals of less than 3 min in group AL was 0 (0%), group USG PL 2 (8%), group USG RT 1 (4%) and p-value 0.011, which was significant, while comparing between three groups. The success rate of IJV cannulation in Time intervals of less than 5 mins in group AL was 13 (52%), group USG PL 20 (80%), group USG RT 22 (88%), and the p-value was 0.046, which was significant while comparing between three groups. In our study Success rate of IJV cannulation in Time intervals of more than 10 mins and 15 mins were statistically insignificant (p>0.05) in all three groups [Table 3, Figure 1].

Complications like Carotid artery puncture occurred in three patients, 3 (12%) in the anatomical landmark group and one patient 1 (4%) in each ultrasound group. In contrast, Hematoma at the puncture site occurred in 2 (8%) patients in the anatomical landmark group, 1 (4%) in Group USG-PL and no such incidence in Group USG-RT.

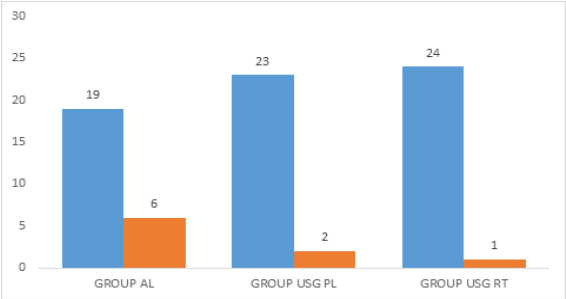

Figure 1: Observation of IJV cannulation success rate in different group patients

Table 1: Observation of demographic parameters of patients in all groups

Parameters	Group AL	GROUP USG-PL	GROUP USG-RT	P value
Age Group				
< 35	7 (28%)	5 (20%)	8(32%)	0.546
36 – 45	11 (44%)	10 (40%)	7 (28%)	
> 45	7 (28%)	10 (40%)	10 (40%)	
Mean Age (years ±SD)	41.28±8.173	44.04±8.537	41.6±11.857	
Gender				
Male	14 (56%)	12 (48%)	10 (40%)	0.527
Female	11 (44%)	13 (52%)	15 (60%)	
Height				
< 160	7 (20%)	12 (48%)	7 (28%)	0.473
> 160	18 (72%)	13 (52%)	18 (72%)	
Mean height (cm± SD)	161.64± 3.936	160.28± 5.481	161.72 ± 4.402	
Weight				
< 50	6 (24%)	5 (20%)	6 (24%)	0.375
51 – 60	11 (44%)	10 (40%)	13 (52%)	
> 60	8 (32%)	10 (40%)	6 (24%)	
Mean weight (kg± SD)	56.28 ±8.453	58.12±7.623	55.04± 7.191	

Table 2: Observation of different evaluation parameters of patients in all groups

Parameters	Group AL	GROUP USG-PL	GROUP USG-RT	P value
Internal Jugular cannulation				
Success	19 (76%)	23 (92%)	24 (96%)	0.071
Failure	6	2	1	
Mean venous Access time (Seconds± SD)	15.32± 6.135	11.16± 4.079	12.36± 2.752	1.0
Catheterization Time (Seconds± SD)				
< 200	15 (50%)	17 (68%)	15 (50%)	0.422
> 200	10 (40%)	8 (32%)	10 (40%)	
Catheterization Attempts				
1	13 (52%)	16 (64%)	20 (80%)	
2	6 (24%)	3 (12%)	2 (8%)	0.106
3	0 (0%)	3 (12%)	2 (12%)	
> 3	6 (24%)	3 (12%)	1 (4%)	

Table 3: Observation of Time Interval of IJV among patients of all three groups

Time Interval Of IJV	Group AL	GROUP USG-PL	GROUP USG-RT	p-value
< 3	0	2	1	0.011*
< 5	13	20	22	0.046*
< 10	20	21	23	0.738
< 15	25	25	25	0.135
Mean± SD	6.44±3.417	5.12±3.456	4.48±2485	

**Statistically significant*

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DISCUSSION

Central venous cannulations are worldwide procedures in every hospital, especially for critically ill patients and all indicated patients. Unfortunately, this procedure has been associated with major risks and complications. In the past, it was done by direct vein cannulation with a large bore metal needle. Later with the introduction of Seldinger's technique, the risks were reduced by using a locating needle followed by internal jugular vein cannulation.[1-3] As anaesthesia has been associated with risks, attempts are being made to provide safe anaesthesia care. Since the introduction of portable bedside ultrasound imaging devices, the scope of ultrasound uses has expanded from diagnostic to therapeutic. Anesthesiologist now uses ultrasound for guiding procedures. The increasing availability of miniature ultrasound units has led to a preference for Ultrasound aided internal jugular vein cannulation among novices at the start of their training.[6,7]

In our study, IJV cannulation was almost possible in all patients. Successful internal jugular vein cannulation was achieved in 76% of the patient in Group AL, 92% in Group USG PL, and 96% in Group USG RT, respectively (p-value 0.071). No statistical significance was noted between the three groups when comparing the successful internal jugular vein cannulation. Our study results in concord with Fathi et al. and Sibai et al.[3,9] They did not find any statistically significant result when comparing the successful internal jugular vein cannulation between the Anatomical landmark technique and Ultrasound guided techniques.

In contrast to our study results, Chuan et al. found a statistically significant difference in success rate between the anatomical landmark technique and the Ultrasound-guided prelocation technique (80% vs 100%) in their randomized controlled study in infants.[10] In our study, the mean venous access time in Group AL was 15.32 seconds, Group USG PL was 11.16 sec, and Group USG RT was 12.36 sec and found to be not statistically significant compared to the three groups. But it was significant (p=0.007) when comparing Group USG PL (11.16 sec) and Group AL (15.32 sec). Our study results are in concordance with the study done by Ghode et al. found there is a significant difference in venous access time while comparing the pre-procedure ultrasound technique and anatomical landmark technique.[11]

In our study, the mean venous access time was statistically significant (p-value 0.033) when compared between Group USG RT (12.36 sec) and Group AL (15.32 sec). Our study results are in concordance with the study done by Denys BG et al. found that average venous access time was 9.8 sec by the ultrasound approach and 44.45 sec by the landmark approach (p<0.001) and concluded that the ultrasound technique decreased venous access time significantly while comparing with anatomical landmark technique.[12]

Our results showed no statistically significant (p=0.22) difference between Group-USG PL and Group-USG RT. Our results concord with the study by Sibai et al. did not find any significant difference in average venous access time between Ultrasound prelocalized and real-time ultrasound groups.[9]

Our study mean catheterization times were in Group AL 182.32 sec, Group USG PL 162.24 secs and Group USG RT 161.72 secs, which was not statistically significant (p=0.422) between the three groups. When catheterization time was compared between the Anatomical landmark technique (Group AL) and real-time ultrasound group (Group USG RT), it was statistically insignificant (p=0.266). Our study results in concord with the study done by Fathi et al., where the results showed that the average time for cannulation was 46.05 sec and 45.46 sec and found no significant statistical difference between both the groups.[3]

Our study's mean catheterization time was 162.24 sec in USG prelocation (Group USG PL) and 161.72 sec in real-time ultrasound technique (Group USG RT), which was not statistically significant (p=0.973) while comparing between two groups. Our results concord with the study by Sibai et al. did not find any significant difference between Ultrasound guided and Ultrasound prelocalized techniques.[9]

Compared to all three groups, successful catheterization in less than three attempts in Group AL 19, Group USG PL 22 and Group USG RT 24 (p=0.106). But when it was compared between Group AL (76%) and Group USG RT (96%), which was statistically significant in the real-time ultrasound group (p=0.029). Our study results in concord with the study done by Troianos et al., a prospective randomized control trial. Their result showed that the USG group had a higher success rate at the first attempt (73%) than the anatomical landmark group (54%).[13] Slama et al. found a statistically significant difference while comparing between ultrasound technique with the anatomical landmark technique.[14]

Our results showed no statistically significant difference (p-value 0.150) between anatomical landmarks and USG-prelocated groups. In contrast to our study results, Chuan et al. showed that the number of attempts was 1.57 in the ultrasound prelocated group and 2.55 in the anatomical landmark technique, which was statistically significant (p<0.001).[10]

No statistically significant (p-value 0.605) difference was found when comparing Group USG PL and Group USG RT. Our study results are in concordance with the study done by Ghode et al. and Sibai et al. were found no statistically significant difference between both ultrasound techniques.[9,11]

The success rate of IJV cannulation in time intervals of less than 3 mins and less than 5 mins was statistically significant (p=0.011 & p=0.046) compared to the three groups. Our study results are in

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concordance with the study done by Ray et al. they found a significant difference while comparing the success rate of IJV cannulation in time intervals of less than 3 mins and less than 5 mins between three groups.[15]

Carotid artery puncture occurred in three patients (12%) in the anatomical landmark group and one (4%) in each ultrasound group. Carotid artery puncture was three times higher in anatomical landmarks than in USG-guided techniques. Our study results are in concordance with the study done by Riaz et al. and Tempe et al. found carotid artery puncture, which was higher in anatomical landmark technique compared with USG guided technique.[5,16]

In contrast to our study results, Babu et al. concluded that real-time ultrasound-guided IJV cannulation reduces the carotid artery puncture but did not wholly eliminate the incidence.[17]

Hematoma at the puncture site occurred in 2 (8%) patients in the anatomical landmark group, 1(4%) patient in Group USG-PL and no such incidence in Group USG-RT. Our results concord with the study by Riaz et al. found that hematoma formation (7% vs 0%) was more frequent in the landmark group than in the Ultrasound-guided group.[16]

Limitations

The study's limitations were a small sample size and a non-blinded assessment of outcomes.

CONCLUSION

In our study, the ultrasound prelocation and the Ultrasound real-time group showed better results when compared to the anatomical landmark group. Venous access time in the ultrasound prelocation group was significantly less than in the Ultrasound real-time group. Catheterization time in the real-time ultrasound group had a better result than the Ultrasound prelocation group. Internal jugular vein cannulation in the ultrasound prelocation group was as effective as in the Ultrasound-guided real-time imaging group.

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