Original Article

Internal jugular vein cannulation: A comparison of three techniques

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Abstract

Context: Ultrasound-guided internal jugular vein (IJV) cannulation is known for increasing success rate and decreasing rate of complications. The ultrasound image can be used as a real time image during cannulation or to prelocate the IJV before attempting cannulation.

Aims: This study compares both the ultrasound-guided technique with the classical anatomical landmark technique (central approach) for right IJV cannulation in terms of success rate, complications, and time for cannulation.

Settings and Design: A prospective, randomized, observational study was conducted at a tertiary care hospital.

Material and Methods: One hundred twenty patients requiring IJV cannulation were included in this study and were randomly allocated in three groups. Number of attempts, success rate, venous access time, catheterization time, and complications were observed in each group.

Statistical Analysis Used: Statistical analysis was performed using STATA-9 software. Demographic data were compared using one-way analysis of variance (ANOVA). Nonparametric data were compared using the Kruskall–Wallis test, and multiple comparisons were done applying The Mann–Whitney test for individual pairs of groups. Nominal data were compared by applying the Chi-square test and Fisher exact test.

Results: Successful cannulation (≤3 attempt) was achieved in 90.83% of patients without any statistical significant difference between the groups. Venous access time and catheterization time was found to be significantly less in both the ultrasound groups than the anatomical land mark group. Number of attempts and success in first attempt was similar between the groups.

Conclusions: Both the ultrasound techniques are found to be better than the anatomical landmark technique. Further, ultrasound-guided prelocation was found to be as effective as ultrasound guided real-time imaging technique for right IJV cannulation.

Key words: Internal jugular vein, ultrasound-guided, venous cannulation

Introduction

Central venous catheterization has specific indications and should be reserved for the patient who has the potential to benefit from it.[1,2] Hermosura *et al*. described right internal jugular cannulation in 1966, and since then it has become one of the most popular route for central venous cannulation.[3] Later many anatomical landmarks guided techniques for internal jugular vein (IJV) cannulation have been described.[4-11]

Real-time ultrasound-guided imaging has been advocated as it improves the success rate, reduces number of attempts and complications rate, and is also helpful in identifying patients in whom cannulation may be difficult. However, its widespread use has been restricted by the impracticality of a specially designed ultrasound machine or sterile scanner manipulation, unavailability of equipment, and trained personnel.[12]

Alternatively, ultrasound imaging can be applied for evaluation of anatomic structures before attempting venous puncture, which helps the clinicians locate the carotid artery and the IJV, and determine the direction and site of venepuncture. However, only few prospective studies exist comparing IJV cannulation by the

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real-time ultrasound imaging, ultrasound-guided prelocation, and the anatomical landmark technique (central approach).

The aim of this study is to compare success rate, complication rate, and time to complete catheterization during right IJV catheterization by using anatomical landmark technique (central approach), ultrasound-guided prelocation technique, and ultrasound-guided real-time technique.

Materials and Methods

After institutional ethics committee approval for this prospective, randomized, observational study, 120 patients aged 15-65 years, scheduled for elective or emergency surgery or during their stay in the intensive care unit (ICU); who required IJV catheterization, were included. Patients were randomly allocated to one of the three groups using closed – envelope method (40 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, and in the last group, ultrasound-guided real-time imaging was used for their right IJV catheter insertion (Group USG-RT). Patients who had a history of previous neck surgery, head and neck mass or cancer, superior vena cava syndrome, coagulopathy, infection at the cannulation site were excluded from the study.

CERTOFIX TRIO V, 7F × 20 cm, triple-lumen central venous pressure (CVP) catheter (B Braun, Melsungen AG, Germany) was used for catheterization in all patients. A 7.5 MHz transducer (Probe) attached to the 2D image display of the ultrasound machine SITE-RITE USG system (Brad access system, Inc. Salt Lake City, United States) was used in this study. Sterile polyethylene sheath to protect the ultrasound probe and ultrasound gel were used in the study.

Standard monitoring (electrocardiogram, blood pressure, and pulse-oximeter) were applied to all patients All patients were positioned in the Trendelenburg (20-30°) position with head turned slightly toward the left side and stabilized with folded towels. Anatomical landmarks (sternocleidomastoid muscles, sternal notch, cricoid cartilage, and clavicle) were assessed and marked. Right side of the neck region was prepared with an antiseptic solution. The procedure was carried out either under general anesthesia or local infiltration with local anesthetic and conscious sedation with intravenous midazolam.

In group AL, An 18G introducer needle attached with a 5 ml 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 20-30° with the skin. In ultrasound-guided technique groups, 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 were 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. Venepuncture site was also determined and marked (Prelocation), and cannulation was performed, and 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. Confirmation of position of the CVP catheter was performed by connecting the catheter to the transducer and obtaining CVP waveform tracing. The CVP catheter was secured with sutures, and a sterile dressing was applied.

Following observation were recorded by an independent observer: Number of attempts, success rate, venous access time, catheterization time. Complications like local swelling, skin hematoma, arterial puncture, pneumothorax, hemothorax, and catheter malposition were also recorded. Inability to cannulate the vein in three attempts was recorded as a failure.

'Venous access time' was defined as the time from the starting of insertion of the introducer needle to the return of dark colored venous blood into the attached syringe. 'Catheterization time' was defined as the time from the starting of insertion of the introducer needle to the end of catheter placement, not including the suturing and fixation time.

Position of tip of the CVP catheter and occurrence of pneumothorax was confirmed by performing chest radiograph. Complications, if occurred were managed according to the standard protocol.

Statistical analysis was performed using STATA-9 software. Demographic data, (age, weight, height, body mass index) were compared using one-way analysis of variance (ANOVA), and sex distribution was compared by using Chi-square test. Nonparametric data (venous access time and catheterization time) were compared using the Kruskall–Wallis test, and multiple comparisons were done applying the Mann–Whitney test for individual pairs of groups. History of the previous calculation, successful cannulation, successful catheterization with the number of attempts, success rate of catheterization in different time interval, catheterization time >15 minutes, and complications (carotid artery puncture, hematoma) 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

For all the 120 patients in the study, right IJV cannulation was possible, irrespective of the number of attempts. Demographic data of all the three groups of the study are summarized in Table 1.

Right IJV cannulation and catheterization characteristics are shown in Table 2. The median venous access time was found to be significant ($P = 0.024$) between the groups. It was found to be shorter in ultrasound groups than in anatomical landmark technique [Table 2]. Percentage of successful cannulation between first, second, and third attempts is summarized in Table 3. There was no statistical significance between the three groups with regard to successful cannulation rate in first attempt. The median catheterization time was found to be short in ultrasound groups compared with anatomical landmark groups ($P = 0.002$) [Table 2].

Similarly, rate of successful catheterization in <3 and <5 minutes were found to be statistically significant between the ultrasound groups [Table 3]. Successful catheterization with <10 and <15 minutes were not statistically significant between the groups [Table 4].

Among the various complications, carotid artery puncture occurred in three patients (7.5%), in the anatomical landmark group, and one patient (2.5%) in each of the ultrasound groups. Hematoma at the puncture site occurred only in one patient in anatomical landmark group.

Discussion

First described in 1984 by Legler and Nugent,[13] ultrasound have been used as either a prelocating device or a real-time guidance device for central venous cannulation. Real-time ultrasound guidance may be provided either through the external application of an ultrasound probe to visualize the vessels or with Doppler probe for identifying needle entry into the vein. National Institute of Clinical Excellence (NICE) guidelines,[14] recommend that, 2D ultrasound should be considered in most clinical circumstances where central venous cannulation is indicated.

IJV cannulation was possible in all of the patients in this study. However, successful IJV catheterization was achieved in 90.85% of patients. The anatomical landmark technique had a successful cannulation of 85%, which is in accordance with the success rate reported in previous studies using anatomical landmarks (85-99%).[4,8,15-17] Success rate in the prelocation group in this study was also found to be consistent with findings of previous studies using a similar technique.[17-22] Most of the studies have not specified the definition of successful cannulation, and it varied from <3 attempts without carotid artery puncture to <7 attempts and some investigators have defined it as access time less than 4 minutes.[12,20,22]

Table 1: Demographic data of the patients in group AL, group US-PL, and group US-RT

Group	Total (*N*=120)	Group AL (*N*=40)	Group US-P (*N*=40)	Group US-RT (*N*=40)	*P*
Sex					
M	77 (64.2%)	28 (70%)	25 (62.5%)	24 (60%)	0.624*
F	43 (35.8%)	12 (30%)	15 (37.5%)	16 (40%)	
Number (%)					
Age (year) Mean+SD)	42.3±15.40	41.1±15.29	44.2±13.32	41.6±17.52	0.630 †
Weight (kg) (Mean+SD)	56.3±13.38	55.8±14.86	57.7±11.95	55.3±13.40	0.710 †
Height (cm) (Mean+SD)	161.7±7.99	161.8±7.33	161.2±8.88	162.0±7.47	0.903 †

*L=Lignocaine, US-PL=Ultrasound-prelocation, US-RT=Ultrasound real-time, All values expressed as mean+SD; N=Number, *Chi-square test, †ANOVA, SD=Standard deviation*

Table 2: Venous cannulation/catheterization characteristics in group AL, group US-PL, and Group US-RT

Success rate/ Time taken	Group AL (*N*=40)	Group US-PL (*N*=40)	Group US-RT (*N*=40)	*P*
Internal jugular cannulation				
Successful	34 (85%)	37 (92.5%)	38 (95%)	0.378*
Failure	6 (15%)	3 (7.5%)	2 (5%)	
Number (%)				
Venous access time (sec) Median (min-max)	14.5 (5-120)	9.5 (4-60)	11 (4-30)	0.024† (1,3) (1,2)
Catheterization time (sec) Median (min-max)	225.0 (90-2480)	167.5 (84-2110)	165 (90-1370)	0.002† (1,3) (1,2)

*L=Lignocaine, US-PL=Ultrasound-prelocation, US-RT=Ultrasound real-time, N=Number, *Fisher's exact test, †Kruskall–Wallis test, with multiple comparisons between groups by adjusted Mann–Whitney test. Figures in bracket (1, 2, and 3) represents, 1=AL group, 2=US-PL group, and 3=US-PL group*

Table 3: Successful catheterization with increasing number of attempts

No. of attempts	AL group *N*=40 (%)	USG-PL group *N*=40 (%)	USG-RT group *N*=40 (%)	*P*
1	25 (62.5)	30 (75)	31 (77.5)	0.6033
2	8 (20)	6 (15)	4 (10)	0.4920
3	0	1 (2.5)	3 (7.5)	0.1697
>3	7 (17.5)	3 (7.5)	2 (5)	0.1616

L=Lignocaine, US-PL=Ultrasound-prelocation, US-RT=Ultrasound real-time, Data is expressed in N (%)

Table 4: Success rate of IJV catheterization in different time interval

Time taken	Group AL *N*=40 (%)	Group US-PL *N*=40 (%)	Group US-RT *N*=40 (%)	*P*
<3 min (%) (*n*)	30 (12)	60 (24)	60 (24)	0.008* (1,3) (1,2)
<5 min (%) (*n*)	62.5 (25)	82.5 (33)	85 (34)	0.033* (1,3) (1,2)
<10 min (%) (*n*)	80 (32)	90 (36)	92.5 (37)	0.302*
<15 min (%) (*n*)	85 (34)	92.5 (37)	97.5 (39)	0.154*

*L=Lignocaine, US-PL=Ultrasound-prelocation, US-RT=Ultrasound real-time, N=Number, *Chi-square test and Fisher's exact test, Figures in bracket (1, 2, and 3) represents, 1=AL group, 2=US-PL group, and 3=US-RT group*

Success rate with real-time ultrasound imaging is also in accordance results of previous studies (94-100%).[15,21-28] Most of the previous studies have not found any significant difference in success rate while comparing different techniques of IJV cannulation. This is mainly due to, requirement of a large sample size, varying definition of successful cannulation and failure in cannulation, and different study population. However, Mallory *et al*. and Denys *et al*. found a significant difference in success rate while comparing the anatomical landmark technique with the ultrasound-guided real-time imaging technique.[15,23] Similarly, Chuan *et al*. found statistically significant difference in success rate between the anatomical landmark technique and the ultrasound-guided prelocation technique (80% vs. 100%) in their study, in infants'.[20] None of these limited studies reported a significant difference in success rate between the groups while comparing the ultrasound-guided prelocation technique and the ultrasound-guided real-time imaging technique.

Both the median venous access time and the median catheterization time in this study were found to be statistically different, which is in accordance with previous studies. Time used for puncture and catheterization has been described in various studies, but the definition varied considerably. Hence, it is difficult to compare data from different studies. None of the reported trials had studied both the venous access time and the catheterization time. In this study, 62% of patients in the AL group in comparison to 75% in the US-PL group, and 77.5% in the US-RT group could be cannulated in first attempt. Previous studies showed similar results of success rate with the first attempt in the anatomical landmark technique (28-87%) and in the ultrasound-guided real-time imaging technique (43-96%).[15,19,21-26,29] One study comparing the anatomical landmark technique vs. the ultrasound-guided prelocation technique found success at the first attempt in the prelocation group to be 75.6%.[19]

Incidence of carotid artery puncture is in accordance with previous studies using similar techniques.[4,12,15,16,18-20,24,25,27,29-31] Hematoma formation occurred only in one patient who belonged to the AL group, which was managed by external compression. Nevertheless, subsequent cannulation was possible in that patient. No other complications were observed in this study. As reported in earlier studies, this study demonstrates that both the ultrasound techniques were found to be more useful in placement of IJV catheters, and decreasing complications. Both the ultrasound techniques not only clarify the relative position of the vein and its surrounding structures, but also help in identifying course of the vein and the artery and their caliber and thereby infuse confidence to the operator.

Cost is one of the limiting factors in the availability of ultrasound device in many clinical setups. A further cost is incurred while using the real-time imaging technique, as specific sterile sheath and jelly are used. As no significant difference in terms of cannulation and complications was observed in this study, we suggest that using prelocation technique will decrease the expenditures.

Chuan *et al*. using a transesophageal echocardiography (TEE) probe for prelocation technique and found prelocation to be equally effective.[18] Ultrasound machine available in operation room or ICUs for other purposes can be used for ultrasound-guided prelocation, thereby increasing successful cannulation, effective utilization of available equipment and avoiding the purchase of additional equipment.

A small sample size, nonblinded assessment of outcomes, and nonmeasurement of the IJV diameter were the limitations of this study.

In conclusion, application of ultrasound-guided techniques increases the success rate of IJV cannulation, decreases complications, and time of catheterization in comparison to anatomical landmark technique. Hence, ultrasound-guided techniques should be used for IJV cannulation when available and ultrasound-guided-prelocation technique can be equally useful as that of real-time imaging technique in all circumstances.

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