Original Article

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A Comparative Study of Right and Left IJV Cannulation Using Surface Anatomy or USG Guidance: A Prospective Randomized Study

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Abstract

Context: Internal jugular vein (IJV) is cannulated in a variety of patients. Left IJV cannulation sometimes becomes necessary. *Aim:* This study was done to evaluate the usefulness of ultrasonography (USG) in performing left and right IJV cannulation compared with use of surface anatomy landmarks. *Setting and Design:* Prospective randomized study in a tertiary care teaching hospital. *Methods:* Ninety one American Society of Anesthesiologists (ASA) class I, II or III adult patients scheduled for elective cardiothoracic, vascular, neurosurgical or major abdominal surgeries requiring IJV cannulation were randomized to undergo either right IJV cannulation using surface landmarks (Group 1) or USG (Group 2) or left IJV cannulation using surface landmarks (Group 3) or USG (Group 4). The number of attempts, time taken, the success rate, any change in technique or side of cannulation and any complications were recorded. *Results:* There was a significant difference in the success rate and number of complication between group 3 and group 4 ($p<0.05$). There was a statistically significant difference in the time taken for cannulation between Group 3 and Group 4 (273.9±127.6 Vs 135.2±105.1 sec, $p<0.001$). There was a significant difference in the number of attempts between Group 1 and Group 2 (2.05±1.2 Vs 1.46±0.64, $p<0.05$) and between Groups 3 and Group 4 (2.78±1.41 Vs 1.69±0.18, $p<0.01$). Complications (carotid puncture) were significantly more common on left side using surface landmarks ($p<0.05$). *Conclusion:* Ultrasound significantly improves the success rate of left and right IJV cannulation when compared to use of surface landmarks. It also reduces the number of attempts, the time required for cannulation and incidence of complications.

Keywords: Cannulation; Central Venous; Jugular; Ultrasonography; Vein.

Introduction

Internal jugular vein (IJV) is cannulated for a variety of indications in perioperative period and in the critically ill. This includes both diagnostic and therapeutic indications. The right IJV is usually chosen because it has a relatively straight course to the heart, has a lesser chance of pneumothorax and avoids the risk of injury to thoracic duct altogether [1,2]. The clinician's experience with right IJV is also commonly greater than with left IJV. However, left IJV cannulation frequently becomes necessary when the right IJV cannulation is unsuccessful or the right IJV is thrombosed or has a catheter in-situ or the right carotid artery is significantly stenosed.

Ultrasonography (USG) greatly improves the success rate and reduces the risks of IJV cannulation, particularly for inexperienced clinicians [3]. And the NICE guidance suggests the two-dimensional (2D) imaging USG as the preferred method for cannulation of the IJV in adults and children in elective situations [4]. However, in majority of studies on use of 2D-USG for IJV cannulation the right IJV was used. Since the left IJV is longer, more tortuous and smaller in calibre than the right IJV, it is more likely to be difficult to cannulate [5]. To our knowledge, there is only one randomized study that compares right and left IJV

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cannulations using surface landmarks or USG [6]. Unlike these authors, in patients scheduled for major elective surgeries we perform IJV cannulations before induction of anesthesia which could affect the results of the study. We performed a randomized study to evaluate the usefulness of real-time USG in cannulation of left or right IJV compared to use of surface landmarks.

The primary objective of our study was to compare the success rate and complications of left and right IJV cannulation using real-time USG versus use of surface landmarks. The secondary objectives was to compare the number of attempts and access times for left and right IJV cannulation performed with or without USG.

Materials and Methods

After Institutional ethics committee approval and written informed consent from each patient a total of 106 ASA class I, II &III patients scheduled for elective cardiothoracic, vascular, neurosurgical and major abdominal surgeries requiring IJV cannulation were enrolled into the study. With the exclusion of 15 patients who did not meet the inclusion criteria, the final study population was 91 patients and was randomly allocated into 4 groups using a computer-generated table of random numbers (Figure 1).

Patients were excluded from randomization if they have had a previous IJV cannulation, neck dissection, burns or radiotherapy to the neck, have a mass or infection at the cannulation site or refuse to participate. Patients underwent either right IJV (RIJV) cannulation using surface landmarks (group 1) or using USG (group 2) or underwent left IJV (LIJV) cannulation using surface landmarks (group 3) or using USG (group 4).

All cannulation were done as per the recommendations and practice guidelines suggested by the ASA Task force on central venous access, under strict aseptic precautions and sterile draping with a slight Trendelenburg positioning and head turned by about 30° to contralateral side, using Seldinger technique. All cannulations were performed by staff anesthesiologists experienced in IJV cannulations and expertise in USG-guided technique.

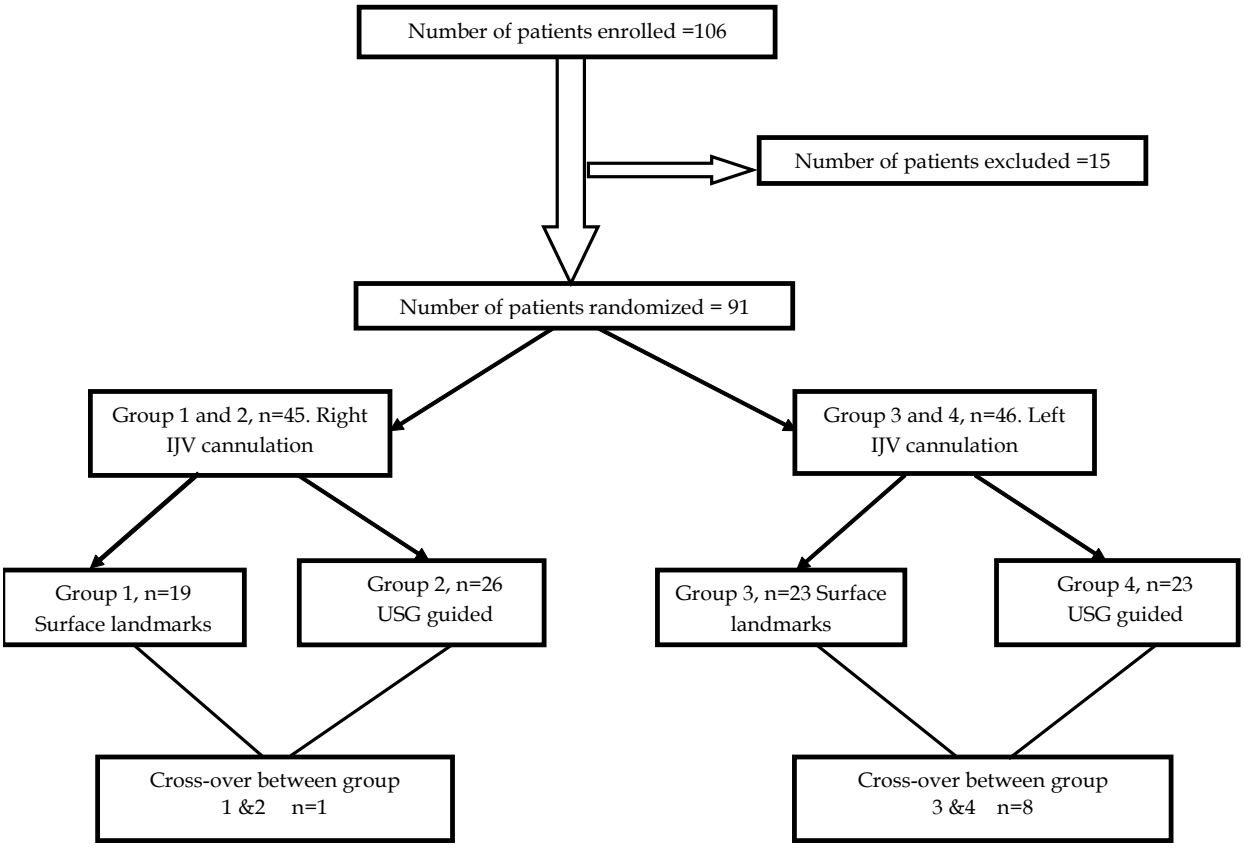

Fig. 1: Study design

Surface Landmark Approach

The site of puncture was the apex of the triangle formed by the clavicle and the two heads of sternomastoid muscle. A 23G locator needle was inserted at an angle of approximately 45° and directed towards the ipsilateral nipple. Aspiration of dark, non-pulsatile blood guided a subsequent 16G cannulating needle in the same direction. A further aspiration of dark, non-pulsatile blood was followed by guidewire insertion through the cannulation needle. And a 7 Fr triple- or double-lumen catheter was inserted over the guidewire (Cetrofix, B. Braun, Melsungen AG, Germany).

An attempt at cannulation was defined as the number of skin punctures and the technique was considered successful if the guidewire was successfully inserted on the ipsilateral side using the technique the patient was randomly assigned to. Whenever the IJV was not located by more than six attempts or there was difficulty in passage of guidewire or there was arterial puncture with the 16G cannulation needle, USG was used to guide ipsilateral IJV cannulation. In the event of guidewire placement using USG being unsuccessful, the contralateral IJV was cannulated under ultrasound guidance.

Ultrasound-Guided Approach

A 7.5MHZ linear array ultrasound transducer probe (Vivid-i) covered in ultrasonic gel was wrapped with a sterile plastic bag and connected to a USG machine (vivid-i, GE Medical Systems, Milwaukee, USA). The probe was placed on the neck at the level of cricoid cartilage and the IJV was then identified by its shape, absent pulsations, probe compressibility and by colour flow Doppler. A 16G cannulating needle was then used to puncture the IJV visualized in short axis in real-time USG. After aspiration of blood, guidewire was inserted and its position confirmed by USG of IJV in long axis.

Data Collection and Analysis

The data collected included the number of successful cannulations in each group, number of attempts, time taken from initial skin puncture to successful guide wire placement, incidence of complications such as arterial puncture, hematoma and pneumothorax, and the number of patients in whom cross-over of technique was used. Post-procedure chest X-ray films were taken routinely. Data analysis was done using STATA statistical software version 19.0., independent sample T-test for continuous variables and chi- square test for categorical variables.

Results

There was no statistically significant difference among the groups with respect to age, gender distribution, weight or height (Table 1). There was a significant difference in the success rate and number of complication between group 3 and group 4 ($p<0.05$). However, there was no significant difference in the success rate or complications between group 1 and group 2 (Table 2). The only complication observed in our study was carotid artery puncture. One patient in group 1 and 8 patients in group 3 had carotid puncture. Cannulation in these patients was accomplished using USG on the same side. None of the patients developed hematoma. Also the success rate was significantly higher in group 1 compared to group 3.

There was a significant difference in the number of attempts between group 1 and group 2 and between group 3 and group 4 (Table 3). There was no significant difference in the number of attempts between group 2 and group 4. Using surface landmarks, cannulation of the LIJV took significantly more time compared to RIJV. Ultrasonography greatly reduced the time taken for cannulation on left side compared to surface landmark (Table 3, Figure 2).

Table 1: Patient demographics

	IJV		LIJV	
	Group 1 (SL, n=19)	**Group 2 (USG, n=26)**	**Group 3 (SL, n=23)**	**Group 4 (USG, n=23)**
Age (yrs)	51.4±12.0	56.9±13.0	49.8±10.2	56.56±10.0
Gender				
Male	14	19	17	17
Female	5	7	6	6
Weight (kg)	63.6±7.0	64.3±5.1	65.2±6.2	64.4±7.3
Height (cm)	171.3±3.0	172.6±2.3	173.0±2.1	171.8±2.6

RIJV: right internal jugular vein, LIJV: left internal jugular vein, SL: surface landmark, USG: ultrasonography

Table 2: Success rate and complications

Group	Success rate (%)	Complication (%)
Group 1	94.7#	5.3
Group 2	100	0.0
Group 3	65.2	34.8
Group 4	100	0.0

*p<0.05 compared to group 3, #p<0.05 compared to group 3

Table 3: Number of attempts and access times

Group	Number of attempts (mean ± SD)	Access time (sec, mean ± SD)
1	2.05 ± 1.22	172.4 ± 213.6
2	1.46 ± 0.64*	136.5 ± 122.9
3	2.78 ± 1.41	273.9 ± 127.6†
4	1.69 ± 0.18#	135.2 ± 105.1#

*p<0.05 compared to group 1, †p<0.05 compared to group 1, #p<0.01 compared to group 3

Table 4: Success in multiple attempts among groups

Group	Success in 1st attempt, n (%)	Success in two attempts, n (%)	Success in three attempts, n (%)
1	9 (47.4%)	12 (63.1%)	17 (89.4%)
2	16 (61.5%)	24 (92.3%)*	26 (100%)
3	6 (26.1%)	9 (39.1%)	16 (69.7%)
4	13 (56.5%)#	17 (73.9%)#	23 (100%)#

*p<0.05 compared to group 1, #p<0.05 compared to group 3 at respective number of attempts

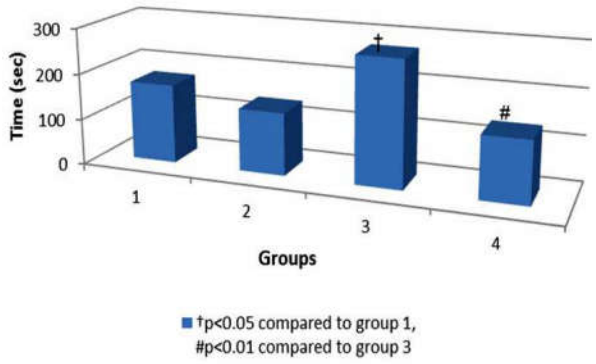

Fig. 2: Access time

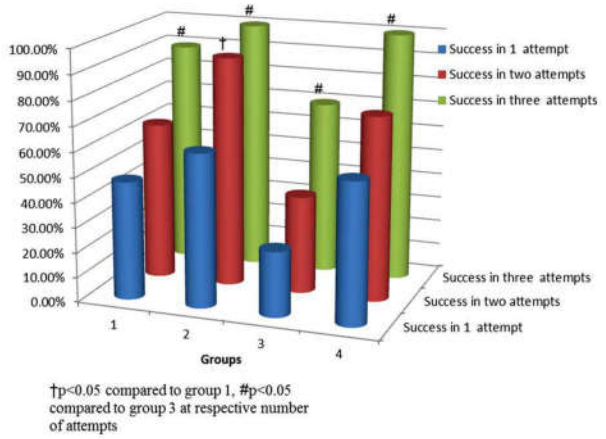

Fig. 3: Cumulative success in multiple attempts

We also evaluated the usefulness of ultrasonography in improving the success rate with every attempt at cannulation after a failed first attempt. Cumulative success in one, two and three attempts is shown in Table 4, and Figure 3. There was a significant improvement in the success rate in upto 3 attempts in group 4 compared to group 3. On the right side, USG improved the success rate in two attempts at cannulation (Table 4, Figure 3).

Discussion

Our study showed that ultrasonography significantly improves the success rate and reduces the complications of left IJV cannulation. On the right side however, the success rate and complications were not different statistically with or without USG, probably because all the cannulations were done by faculty with vast experience in IJV cannulations. Our success rate of right IJV cannulations is comparable with previous studies [7,-9]. Denys and Uretsky have shown that IJV is located anterolateral to the carotid artery (CA) in 92%, >1 cm lateral to the carotid in 1%, medial to the carotid in 2%, and outside of the path predicted by surface landmarks in 5.5% of patients [10]. A failure rate of 7.0% to 19.4% is due partly to the inability of external landmarks to precisely correlate with the location of the vessel [11,12]. The

failure rate of 5.3% on right side using surface landmarks in our study is well within this range.

Using surface landmarks, the left IJV was more difficult to cannulate compared to the right IJV. It took more time and attempts to cannulate the left IJV than the right IJV using surface landmarks. This may be due to its longer and more tortuous course compared to right IJV. In addition, the vertical and horizontal diameter of left IJV is smaller than the right IJV as measured by preoperative CT scans [13]. Left IJV also lies deeper compared to right IJV. On the right side USG did reduce the number of attempts compared to surface landmarks.

Our study also showed that when multiple attempts are made at cannulation of left IJV, a USG-guided technique is more likely to succeed than a surface landmark guided technique. Since there is a strong direct correlation between the number of attempts and the incidence of complications, increasing patient anxiety and discomfort, it may be prudent to use USG for all left IJV cannulations. Patient head position also has important implications for the relation between CA and IJV. Sulek CA *et al* have shown that the percentage of overlap between the IJV and the CA increased as the head was rotated contralaterally from neutral (0°) to 40° to 80° [14]. When overlap occurred, it was always more on the left than the right side, and it was significant at 80 degrees head rotation ($P < 0.05$). In our study patient head was rotated by about 30°. The concern with overlap of IJV and CA is that it increases the likelihood of unintentional CA puncture by a through-and-through puncture of the IJV. The accidental puncture of the posterior wall of IJV can occur even with the use of USG when short axis view is used for the cannulation [15]. As the advancing needle indents the anterior wall of the low-pressure IJV, it collapses and in the absence of blood aspired from the needle the advancing needle could puncture the posterior wall of IJV and then the CA. Vessel overlap increasing with head rotation is most apparent among patients with increased body surface areas (>1.87 m^2) and increased body mass indexes (>25 kg/m^2) [16]. The 5.2% right CA puncture incidence in our study is much less compared to those reported in previous studies [7-9]. This may be because of several factors including experienced operators, low mean body mass index (BMI) among our study groups of 21.7kg/m^2 and head turned to contralateral side by about 30°. The incidence of CA puncture on the left side using surface landmarks was 34.8 % which is high compared to a previous study [6], probably because of a smaller sample size and our lack of familiarity with the left IJV cannulations using surface landmarks. Ultrasound can be used to alter the approach angle to avoid CA puncture by directing the advancing needle away from the CA [17]. In our study, there was no incidence of CA puncture using USG on right or left side.

Our study showed that USG-guided cannulation provides advantage of increased success rate with decreased number of attempts and complications compared to the use of surface landmark as shown in previous studies [18-19]. Ultrasound has a definite role in achieving vascular access for difficult-to-cannulate patients with increased success rate and decreased complications. However, USG is a specialized technique and requires advanced training and knowledge [20]. Continued training of physicians in USG techniques ensures that it can be used in various clinical applications to improve the patient outcome.

Conclusion

Ultrasound significantly improves the success rate of left and right IJV cannulation when compared to use of surface landmarks. It also reduces the number of attempts, the time required for cannulation and incidence of complications. Since the left IJV is more difficult to cannulate and has a higher potential for complications than the right IJV, it may be prudent to use USG for all left IJV cannulations.

Key Message

The left IJV is particularly difficult to cannulate using surface landmarks and has higher potential for complications. Hence, USG should be used in all left IJV cannulations

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