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## SCIENTIFIC ARTICLES

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# ULTRASOUND EVALUATION OF THE ANATOMICAL CHARACTERISTICS OF THE INTERNAL JUGULAR VEIN AND CAROTID ARTERY

- Facilitation of Internal Jugular Vein Cannulation -

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### Abstract

**Background and Purpose:** Literature review revealed major variations in the anatomic characteristics of the right internal jugular vein (IJV) and carotid artery (CA) by the use of the ultrasound machine. The purpose of this study is to examine the anatomical characteristics of the right IJV and CA and to evaluate the IJV cannulation outcomes by the standard ultrasound guided vs. ultrasound localized technique as suggested by Lin and colleagues. Additionally, the study assessed the impact of changing the ultrasound transducer direction on the location of right IJV relative to the CA

**Methods:** Patients (n = 100) were randomly assigned to either and ultrasound-guided or ultrasound-localized technique for IJV cannulation. The 'Site Rite' II ultrasound transducer was directed perpendicular to the floor at the apex of the clavicle-sternocleidomastoid triangle at the level of the cricoid cartilage with the head turned to contralateral side of cannulation and table tilted to 30° in Trendelenburg position. Cannulation outcomes, including successful cannulation, access time, success time, and

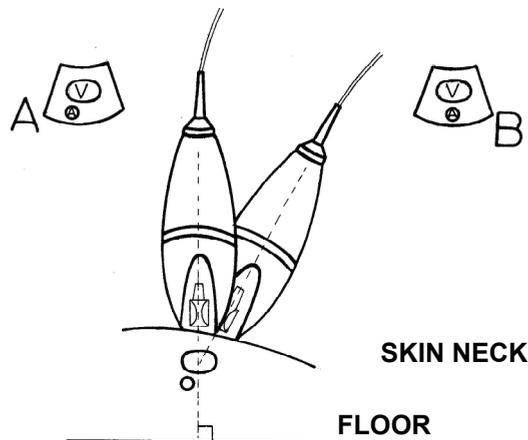
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difficult cases were evaluated. Aborted difficult cases included prolonged procedural time exceeding four minutes and carotid puncture, and these were examined by technique, IJV size and its location relative to CA. The location of the IJV relative to CA was evaluated firstly with the ultrasound transducer directed perpendicular to the floor and secondly with the transducer directed perpendicular to the skin (Fig 1).

*Fig 1*

*Illustration of the directions of ultrasound transducer probe when positioned over the apex of the clavicle-sternocleidomastoid triangle at the level of the cricoid cartilage. Greater anterolateral and total overlap of the IJV relative to the CA is shown when the ultrasound transducer is directed perpendicular to the neck skin (B) compared to when the ultrasound is directed perpendicular to the floor (A).*



**Results:** With the ultrasound transducer directed perpendicular to the floor, the depth of the IJV from the skin (15 mm) was comparable to its diameter (14.1 mm), while the CA A-P diameter was around half that of the IJV (7.4 mm) (Table 2). Also, the majority of patients showed lateral (51%) and posterolateral (14%) positions of the IJV relative to the CA. Directing the transducer perpendicular to the skin resulted in more anterolateral positions (77%) with 6% total overlap. Cannulation of the IJV was successful in 94% in both randomization groups, with 91.5% of the patients achieving first pass cannulation in the ultrasound-guided group and 87.2% in the ultrasound-localized (Table 3). Access time ( $6.9 \pm 13$  sec

and  $5.9 \pm 14.6$  sec) and success time ( $13.5 \pm 14.2$  sec and  $13.2 \pm 15.0$  sec) were comparable for both groups. Reasons for aborted difficult cannulation included prolonged procedural time in 2% and carotid puncture in 4%, in both techniques. Compared to the successful cases, difficult cases were characterized by a significantly greater degree of anterolateral (exceeding  $15^\circ$ ) location of the IJV relative to the CA (p-value=0.046) and a significantly smaller IJV size (mean 10.3 mm vs. 14.3 mm, p-value = 0.035) (Table 4). However, in multivariate analysis controlling for the technique utilized, only the relation between the size of IJV and the occurrence of difficult cases remained significant. With each 1 mm decrease in IJV size, there was a 37% significant increase in the risk of difficult cases.

**Conclusions:** Findings of the study show that both ultrasound guided and ultrasound localized techniques yield similar cannulation outcomes. Additional to the anterolateral position of the IJV relative to the CA, a small IJV size constitutes a powerful predictor for the incidence of prolonged procedure time and carotid puncture for IJV cannulation. Finally, the transducer direction has a significant impact on the assessment of the location of the IJV relative to the CA.

### **Key words:**

Ultrasound, internal jugular vein, venous access, cannulation, difficulties

### **Introduction**

The 'Site Rite' ultrasound imaging system is used for direct visualization of the internal jugular vein (IJV) and carotid artery (CA), and provides continuous guidance for IJV cannulation. In comparison to the blind external landmark technique, the ultrasound-guided cannulation has been shown to be superior. Success rate, access time, number of pricks to the skin, first pass cannulation and carotid puncture rate, were shown to favor the ultrasound-guided technique in several randomized clinical

studies and in a review article.<sup>1-5</sup> While the use of 'Site Rite' ultrasound device reduces complication risks, marking the position of the IJV on the skin using ultrasound followed by blind puncture might be an alternative method (ultrasound-localized technique).<sup>6</sup>

Earlier reports have suggested a number of factors implicated in difficult IJV cannulation, including anterior location of the IJV relative to the CA, small IJV size, neck obesity, and difficult surface landmarks<sup>3,7-10</sup>. Nevertheless, none has examined their relative contribution to cannulation outcomes, simultaneously.

The present study was performed to examine the right IJV and CA anatomic characteristics and their location relative to each other while directing the ultrasound transducer perpendicular to the floor. Also, it evaluated the cannulation outcomes of the IJV by the use of ultrasound-guidance versus ultrasound-localization and examined the relative contribution of anatomical variations to the risk of cannulation difficulties. Additionally, the location of the right IJV relative to the CA was re-evaluated by directing the ultrasound transducer vertical to the neck skin and compared to that observed when directing the transducer perpendicular to the floor (Fig 1).

## **Methods and Materials**

### *Patients*

A total of 100 patients undergoing right internal jugular vein catheterization for a variety of surgical operative procedures were studied (65 males, 35 females). Patients were randomized to receive either ultrasound-guided cannulation or ultrasound localization, followed by blind cannulation of right IJV. The study was approved by the University Institutional Review Board, and an informed consent was obtained from all patients.

General anesthesia was induced intravenously by xylocaine 1.5mg/kg, propofol 2mg/kg, fentanyl 2ug/kg, cisatracurium 0.15mg/kg. The patient was intubated and ventilated using intermittent positive pressure

ventilation. Consequent to stabilization, the right internal jugular vein cannulation was performed while the patient was in the supine position, with his/her right upper limb situated adjacent to body and head tilted to the opposite side of the cannulation. The operating table was tilted to 30° in Trendelenburg position. The IJV and CA assessments and IJV cannulation were done by one operator (EL) who had four years of postgraduate training in anesthesia and an adequate experience in IJV access and ultrasound-guided technique.

### *Ultrasound machine and technique*

We used a real time ultrasound imaging system (Site Rite II, Dymax Corporation, Pittsburgh PA) with a 7.5-MHz mechanical sector scan transducer probe connected to a two-dimensional ultrasound device with a cathode ray tube (CRT) screen. A non-disposable needle guide was attached to the transducer such that the introducer needle intersects in the center of the ultrasound image at 1.5 cm below the transducer surface. The 1-cm markers on the screen and calipers were utilized to estimate the distance of the IJV from the skin (depth) and its diameter (size) as well as the size of the CA. All measurements were taken in the anterior-posterior (A-P) direction.

The location of the IJV was assessed by placing the ultrasound transducer probe over the apex of the clavicle-sternocleidomastoid triangle leveled with the cricoid cartilage in two directions: firstly directed perpendicular to the floor and intersecting with the long axis of the neck at right angle, and secondly perpendicular to the skin (Figure 1). The location of the IJV relative to the carotid artery was classified as follows:

1. Posterolateral (the IJV is lateral and below the horizontal axis of the CA)
2. Lateral, the IJV is lateral and on the same horizontal axis of the CA
3. Anterolateral (up to 15°), the IJV is lateral and up to 15° above the

horizontal axis of the CA

4. Anterolateral (up to 45°), the IJV is lateral and between 15° and 45° above the horizontal axis of the CA
5. Anterior (less than 90°), the IJV is anterior and between 45° and 90° above the horizontal axis of the CA, and
6. Total overlap, the IJV and the CA share a common vertical axis.

The patient's right-side neck was sterilized with Povidone-Iodine solution, draped and dampened with sterile saline solution. The puncture site in both techniques was the apex of the triangle formed by the clavicle, the sternal head, and the clavicular head of the sternocleidomastoid muscle at the level of the cricoid cartilage.

#### *Ultrasound-guided technique*

The ultrasound transducer was placed in its sterile plastic bag with ultrasonic gel. An 18 gauge radio-opaque catheter 6.35 cm over 20 gauge introducer needle (Arrow International®) connected to a 5-ml syringe was used to continuously locate and cannulate the IJV utilizing the non-disposable needle guide on the ultrasound transducer. The transducer was directed perpendicular to the floor and the view was followed continuously on the CRT screen.

#### *Ultrasound-localized technique*

The patient's right-side neck was dampened with sterile saline solution. The ultrasound transducer probe was directed perpendicular to the floor such that the IJV was seen in the middle of the CRT screen. The puncture site was marked on the skin with a permanent-marker pen and the needle guide direction was recognized and memorized accordingly. This was repeated twice to ensure proper localization. The ultrasound transducer probe was removed and the neck area was prepped and draped sterilely. Furthermore, the patient's head position and arm were kept unchanged and, without stretching the neck's skin, the IJV was accessed in the identified direction using the catheter and introducer needle described before.

## Data collection and analysis

Patient characteristics including age, sex, BMI, operative procedure and neck anatomical landmarks were recorded. The latter included characterization of the neck classified as normal, long, short, obese, and short-obese as well as inability to rotate the head. IJV depth relative to skin, its size and the CA size were recorded in mm. The number of pricks to the skin and the number of attempts from skin to the vein were also recorded. Access time (skin to vein) was defined as the time between skin puncture and venous blood aspiration. Success time was defined as the time between skin puncture and catheter cannulation of the IJV as denoted by free venous blood aspiration. Time was measured in seconds using a stopwatch monitored by an assistant. Carotid artery puncture, noted by bright red blood aspiration, was recorded. IJV cannulation was considered 'aborted' when access time exceeded four minutes (prolonged access time) or in case of carotid puncture.<sup>1,3</sup> Aborted cases were not included in the calculation of average number of attempts, access time or success time.

Means (SD) and relative frequencies are presented for continuous and categorical variables, respectively. Differences in baseline characteristics and cannulation outcomes between the two techniques were tested using Student's unpaired *t*-test, Mann-Whitney, Chi-squared or Fisher's Exact test, as appropriate. To examine the association between the risk of aborted cases and IJV anatomic variations (IJV size and IJV location relative to CA), multivariate logistic regression analysis controlling for technique was used. IJV size was entered into the model as a continuous variable and an IJV anterolateral location of more than 15° relative to the CA was considered an 'unsafe' IJV anatomic characteristic. Odds ratios (OR) were estimated and a *p*-value < 0.05 was considered significant. All analysis was conducted using STATA (Release 4.0).

## Results

The majority of the patients were males (65%) with a mean age of 56.3 years (SD = 15.3). These were admitted for various surgeries necessitating access to the IJV (Table 1). Over half of the patients were characterized

by having normal neck (55%), long (10%), short (13%), obese (12%) and short and obese neck (10%) characterized the remaining subjects. The study sample included 9% cases with inability to rotate the head to the contralateral side of the cannulation. The two randomization groups were not significantly different with respect to gender, age, body mass index or neck characteristics.

Table 1.  
Baseline characteristics of patients

| Variable                                    | Total<br>(N = 100) | Technique                     |                                  |
|---|--------------------|-------------------------------|----------------------------------|
|   |                    | Ultrasound-guided<br>(n = 50) | Ultrasound-localized<br>(n = 50) |
| <b>Baseline characteristics of patients</b> |                    |                               |                                  |
| Males (%)                                   | 65                 | 64                            | 66                               |
| Age in years: mean $\pm$ SD                 | 56.3 $\pm$ 15.3    | 57.5 $\pm$ 14.6               | 55.0 $\pm$ 15.92                 |
| BMI in kg/m <sup>2</sup> : mean $\pm$ SD    | 27.1 $\pm$ 4.9     | 27.2 $\pm$ 4.5                | 27.0 $\pm$ 5.4                   |
| <b>Operation (%)</b>                        |                    |                               |                                  |
| Abdominal                                   | 14                 | 8                             | 20                               |
| Neurosurgical                               | 15                 | 16                            | 14                               |
| Urological                                  | 12                 | 14                            | 10                               |
| CABG  | 37                 | 42                            | 32                               |
| Valve replacement                           | 14                 | 14                            | 14                               |
| Peripheral vascular                         | 3                  | 4                             | 2                                |
| Orthopedic                                  | 5                  | 2                             | 8                                |
| <b>Neck characteristics</b>                 |                    |                               |                                  |
| Neck (%)                                    |                    |                               |                                  |
| Normal                                      | 55                 | 58                            | 52                               |
| Long  | 10                 | 10                            | 10                               |
| Short                                       | 13                 | 10                            | 16                               |
| Obese                                       | 12                 | 8                             | 16                               |
| Short and obese                             | 10                 | 14                            | 6                                |
| Inability to rotate head (%)                | 9                  | 8                             | 10                               |

The anatomical measurements of the right IJV and carotid artery are presented in Table 2. The mean IJV anterior-posterior (A-P) depth from the skin was estimated at 15.0 mm (SD = 3.6). Its A-P diameter ranged between 6 and 26 mm with a mean of 14.1 (SD = 4). The majority of the patients (80%) had an IJV size between 10 and 19 mm. The mean carotid artery A-P diameter was 7.4 mm (SD = 1.4).

With the ultrasound transducer directed perpendicular to the floor, the IJV was in the lateral location relative to the CA in the majority of

the patients (51%) (Table 2). Anterolateral locations did not exceed 35% and there were no cases of total overlap. On directing the transducer perpendicular to the skin, the IJV relative to the CA showed a higher extent of anterolateral and anterior locations (77%) with an additional 6% of total overlap. The IJV relative locations to the CA were significantly different between the two directions of the transducer ( $p < 0.001$ ).

Table 2  
Right IJV and carotid artery characteristics

| Variable   | Total<br>n = 100<br>% |
|--|-----------------------|
| <b>Anatomical characteristics</b>  |                       |
| IJV A-P depth from skin in mm  |                       |
| Mean $\pm$ SD  | 15.0 $\pm$ 3.6        |
| (range)  | (7-25)                |
| IJV A-P diameter in mm   |                       |
| <10  | 10.0                  |
| 10-14  | 43.0                  |
| 15-19  | 37.0                  |
| >19  | 10.0                  |
| Mean $\pm$ SD  | 14.1 $\pm$ 4.0        |
| (range)  | (6-26)                |
| Carotid A-P* diameter in mm:   |                       |
| Mean $\pm$ SD  | 7.4 $\pm$ 1.4         |
| (range)  | (5-11)                |
| <b>Location of the IJV relative to CA at the apex<br/>of the clavicle-sternocleidomastoid triangle</b> |                       |
| Ultrasound directed perpendicular to floor   |                       |
| Posterolateral   | 14                    |
| Lateral  | 51                    |
| Anterolateral, up to 15°   | 16                    |
| Anterolateral, up to 45°   | 17                    |
| Anterior, less than 90°  | 2                     |
| Total overlap  | 0                     |
| Ultrasound directed perpendicular to skin  |                       |
| Posterolateral   | 6                     |
| Lateral  | 11                    |
| Anterolateral, up to 15°   | 31                    |
| Anterolateral, up to 45°   | 38                    |
| Anterior, less than 90°  | 8                     |
| Total overlap  | 6                     |

\* A-P: anterior-posterior

Cannulation of the IJV was carried out with the patient head turned to the left side, transducer directed perpendicular to the floor at the apex of the clavicle-sternocleidomastoid triangle and at the level of the cricoid with the operating table tilted to 30° in Trendelenburg position. The right

IJV cannulation outcomes in the total sample and in the ultrasound-guided group compared to those in the ultrasound-localized group are presented in Table 3. The skin prick site was not changed in 98% of the cases. Following the study protocol guidelines, cannulation was aborted due to prolonged access time exceeding 4 min in two patients (2%) and due to carotid artery puncture in another four (4%). Among subjects with successful IJV cannulation (94%), the vein was entered on the first attempt in 89.4% and on the second attempt in 7.4%. Average access time (skin to vein) was 6.4 sec (SD 13.7) and average success time was 13.3 sec (SD = 14.5). There was no significant difference in any of these outcomes between patients undergoing ultrasound-guided and ultrasound-localised blind technique.

Table 3  
Right IJV cannulation outcomes using the ultrasound-guided  
versus ultrasound-localized technique

| Variable                             | Total Sample    | Technique         |                      | p-value |
|--------------------------------------|-----------------|-------------------|----------------------|---------|
|                                      |                 | Ultrasound-guided | Ultrasound-localized |         |
|                                      | %               | %                 | %                    |         |
| <b>Number of skin pricks</b>         |                 |                   |                      |         |
| One                                  | 98.0            | 96.0              | 100.0                | 0.495   |
| Two                                  | 2.0             | 4.0               | 0.0                  |         |
| <b>Cannulation outcome</b>           |                 |                   |                      |         |
| Successfully cannulated IJV          | 94.0            | 94.0              | 94.0                 | 1.000   |
| Aborted cases                        |                 |                   |                      |         |
| Prolonged access time                | 2.0             | 2.0               | 2.0                  |         |
| Carotid puncture                     | 4.0             | 4.0               | 4.0                  |         |
| <b>Successfully cannulated cases</b> |                 |                   |                      |         |
| <b>Attempts with success</b>         |                 |                   |                      |         |
| One                                  | 89.4            | 91.5              | 87.2                 | 0.770   |
| Two                                  | 7.4             | 6.4               | 8.5                  |         |
| Three or more                        | 3.2             | 2.1               | 4.3                  |         |
| Mean $\pm$ SD                        | 1.19 $\pm$ 0.75 | 1.13 $\pm$ 0.49   | 1.26 $\pm$ 0.94      | 0.717   |
| <b>Access time (sec)</b>             |                 |                   |                      |         |
| Mean $\pm$ SD                        | 6.4 $\pm$ 13.7  | 6.9 $\pm$ 13.0    | 5.9 $\pm$ 14.6       | 0.715   |
| (range)                              | (2-101)         | (2-91)            | (2-101)              |         |
| <b>Success time (sec)</b>            |                 |                   |                      |         |
| Mean $\pm$ SD                        | 13.3 $\pm$ 14.5 | 13.5 $\pm$ 14.2   | 13.2 $\pm$ 15.0      | 0.921   |
| (range)                              | (5-106)         | (5-93)            | (6-106)              |         |

Compared to successful IJV cannulations, aborted cases were significantly more likely to include subjects with anterolateral locations of more than 15° (15.8% vs. 3.7%, p-value = 0.046) and were characterized by a significantly smaller IJV A-P size (10.3 mm vs. 14.3 mm, p-value =

0.035) (Table 4). In the multivariate analysis, however, findings showed that the association remained significant for IJV size only. The risk of aborted cases significantly increased with decrease in the IJV size (OR = 1.37,  $p$ -value = 0.037).

*Table 4*  
*Results of bivariate analysis and multivariate logistic regression:*  
*predictors of aborted difficult cases*

|                                       | Bi-variate analysis |      |          |      |              | Multivariate        |            |
|---------------------------------------|---------------------|------|----------|------|--------------|---------------------|------------|
|                                       | Successful          |      | Aborted* |      | $p$ -value   | Regression analysis |            |
|                                       | cases               |      | cases    |      |              | OR                  | $p$ -value |
|                                       | no.                 | %    | no.      | %    | multivariate |                     |            |
| <b>Location of IJV relative to CA</b> |                     |      |          |      |              |                     |            |
| Lateral and anterolateral             |                     |      |          |      |              |                     |            |
| up to 15°                             | 78                  | 96.3 | 3        | 3.7  |              |                     |            |
| Anterolateral more than 15°           | 16                  | 84.2 | 3        | 15.8 | 0.046        | 3.31                | 0.187      |
| <b>Size of IJV (continuous)</b>       |                     |      |          |      |              |                     |            |
| Mean±SD                               | 14.3±3.8            |      | 10.3±4.1 |      | 0.035        | 1.37                | 0.037      |
| <b>Technique</b>                      |                     |      |          |      |              |                     |            |
| Ultrasound-guided                     | 47                  | 94.0 | 3        | 6.0  |              |                     |            |
| Ultrasound-focalised                  | 47                  | 94.0 | 3        | 6.0  | 1.000        | 1.49                | 0.667      |

\* Aborted cases included prolonged procedural time exceeding 4 min or carotid puncture

## Discussion

The current study examined the location of the right IJV relative to the CA and their anatomical characteristics and evaluated IJV cannulation outcomes using two different techniques: ultrasound guided versus ultrasound localized.

Findings revealed that the depth of the IJV from the skin (15 mm) was comparable to its diameter (14.1 mm), while the CAA-P diameter was around half that of the IJV (7.4 mm). These results are consistent with that reported in the literature under comparable conditions.<sup>2,11</sup> The size of the IJV varies in the literature with mean estimates ranging between 10.2 mm (SD = 3.8 mm) and 17.6 mm.<sup>12, 10</sup> Higher values of IJV size are attributed to the use of Valsalva manoeuvre<sup>10</sup> that tends to increase its size or owing to the proximity of the site of the ultrasound transducer to the clavicle.<sup>13</sup>

In classical anatomy books, the position of the IJV is described as

being lateral to the CA<sup>14</sup>. Using the ultrasound machine, studies, however, have varied in their evaluation of the degree of overlap of the IJV relative to the CA, with some finding the IJV mostly lateral (51.4%)<sup>15</sup> and others mostly anterior to the CA (54%).<sup>11,10,16</sup> Variations in the degree of overlap are attributed to differences in the methods used to assess the location of the IJV including the degree of head rotation and the ultrasound transducer direction. In one study, using Computed Tomography imaging with the patient in supine position and head central, 85.2% of the IJV were found in the lateral position.<sup>17</sup> In another study conducted on healthy volunteers and utilizing ultrasound imaging of the IJV with the transducer directed perpendicular to the spinal axis and the head rotated to the opposite side, the IJV was located laterally in 51.4% and anterolaterally in 42.9%<sup>15</sup>. The differential in the proportion of lateral locations of the IJV between these two studies is likely to be attributed to variations in the degree of head rotation. Also, it has been suggested that older patients are not able to rotate their head to the same degree as younger ones and, consequently, less overlap is expected in older patients.<sup>11</sup> Further analysis of our data have shown that patients with limitation to rotate the head (9 patients) were significantly older than the rest and belonged to the lateral (7 patients) and posterolateral positions of the IJV (2 patients) (data not shown). These results substantiate earlier findings showing less overlap between IJV and CA when the head was rotated 0° compared with a rotation of 80°.<sup>18</sup>

Also, further analysis of our data revealed that patients with short and/or obese neck were more likely to have their IJV located anterolaterally relative to the CA than those with normal and/or long neck (data not shown).

Another important factor that contributes to variations in the degree of IJV overlap with CA, stems from the wide variations in ultrasound transducer position and direction across studies. These include the use of the transducer in the direction of the cannulating needle directed towards the ipsilateral nipple,<sup>11</sup> or positioned as close as possible to the clavicle with different probe sites by different operators.<sup>12</sup> The ultrasound transducer was directed perpendicular to the skin in one study<sup>6</sup> and superior and parallel

to the clavicle in another.<sup>10</sup> In our study, the head was turned, as possible, to the contralateral side of cannulation, and evaluation of the location of the IJV relative to the CA was examined by one operator providing a simple visual spot assessment of the position of the IJV. Findings of our study have shown that the degree of IJV overlap with the CA varies by the ultrasound transducer direction. When the transducer was directed perpendicular to the floor, the majority of our patients showed lateral (51%) and posterolateral position of the IJV (14%) with 0% total overlap. On directing the transducer perpendicular to the skin, there was a greater overlap with the IJV being located anterolaterally in the majority of the cases (77%) and an additional (6%) total overlap (Table 2 and Figure 1).

Success rate, number of attempts, time needed to access the IJV and complications utilizing ultrasound machine have been described in the literature<sup>3,19</sup>. In our study, 94% of the cases were successfully cannulated in both randomization groups with time not exceeding two minutes (93 sec in the ultrasound-guided cannulation and 106 sec in the ultrasound-localized). Among the successfully cannulated cases, 91.5% and 87.2% were respectively cannulated with a single pass. These results are comparable to those reported previously for the proportion of successful first pass cannulations using ultrasound-guided technique (range 73% to 92%).<sup>1-4,20</sup> The low proportion of cases needing a second skin prick (2%) indicates that the use of the ultrasound 'Site Rite' machine is satisfactory for localization of the site for access of the IJV. Our estimates of the average number of passes needed for successful cannulation was slightly higher in the ultrasound-localized group ( $1.26 \pm 0.94$ ) than in the ultrasound-guided ( $1.13 \pm 0.49$ ) and these are comparable to published data (range  $1.3 \pm 0.8$  to  $1.4 \pm 0.7$ ).<sup>1,3</sup>

With the use of ultrasound for cannulation of IJV, the incidence of carotid puncture varies in the literature from as low as 0%,<sup>4,21</sup> to 1.7%,<sup>3</sup> 3.2%<sup>7</sup> 5.9%<sup>2</sup> and up to 10.8%.<sup>22</sup> In our study, CA puncture occurred in two patients in each group, ultrasound-guided and ultrasound localised (4%). Complication rate may be influenced by the experience of the operator, being double in the case of inexperienced staff.<sup>19</sup> Studies have also noted

patient features and IJV anatomical variations such as size and degree of overlap with the CA, as factors that may account for complications and inability to cannulate. It has been suggested that an overlap between the IJV and CA is considered a 'dangerous' anatomic position for CA puncture.<sup>3,7,10,11</sup> Nevertheless, there has been no consensus in the literature of what constitutes a 'difficult' case,<sup>9</sup> and none of the studies have examined the relative contribution of these anatomical variations to the risk of complications.

In this study, 'difficult cases' were defined to include those with prolonged procedural time exceeding 4 minutes or CA puncture, whereby IJV cannulation was aborted. Compared to the rest, examination of the difficult cases revealed a significantly greater degree of IJV overlap (anterolateral exceeding 15°) relative to CA. Additionally, difficult cases were characterized by a significantly smaller IJV size (mean size 10.3 mm vs. 14.3 mm). However, in multivariate analysis controlling for the technique utilized, only the relation between the size of IJV and the occurrence of difficult cases remained significant. With each 1 mm decrease in IJV size, there was a 37% significant increase in the risk of difficult cases.

In conclusion, findings of the present study suggest that, in the absence of the sterile sheath needed for the ultrasound guided technique, the ultrasound localized technique can be safely used for the IJV cannulation. The operator using the ultrasound 'Site Rite' machine needs to be cautious when visualizing anterolateral position (more than 15°) of the IJV relative to the CA and more importantly when encountering a small IJV size, both of which being predictors of difficult IJV cannulation. The authors recommend the ultrasound transducer to be directed perpendicular to the floor at the apex of the clavicle-sternocleidomastoid triangle, as this direction is more likely to yield lateral location of the IJV relative to the CA, thus facilitating safe IJV cannulation. Finally, patients with inability to rotate the head have more lateral positions of IJV, while short and/or obese neck have more anterolateral positions of IJV relative to the CA.

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