Comparison between long- and short-axis techniques for ultrasound-guided cannulation of internal jugular vein

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ABSTRACT

**Context:** Real-time ultrasound guidance for internal jugular (IJ) vein cannulation enhances safety and success. **Aims:** This study aims to compare the long- and short-axis (LA and SA) approaches for ultrasound-guided IJ vein cannulation. **Subjects and Methods:** Patients undergoing surgery and in intensive care unit requiring central venous cannulation were randomized to undergo either LA or SA ultrasound-guided cannulation of the IJ vein by a skilled anesthesiologist. First pass success, the number of needle passes, time required for insertion of guidewire, and complications were documented for each procedure. **Results:** The IJ vein was successfully cannulated in all patients. There are no significant differences between the two groups in terms of gender, diameter of IJ vein, margin of safety, and time required for insertion of guidewire. There was also no significant difference between the two groups in terms of side of IJ vein cannulated, patient on mechanical ventilation, number of skin puncture, number of needle redirections, first pass success, and carotid puncture. However, there is a significant relationship between the diameter of IJ vein with first pass success (18.18 ± 4.72 vs. 15.21 ± 4.24; *P* < 0.004) and margin of safety with incidence of carotid puncture (12.15 ± 4.03 vs. 6.59 ± 3.13; *P* < 0.016). **Conclusions:** Both techniques have similar outcomes when used for IJ vein cannulation.

Key words: Internal jugular vein; Scanning axis; Ultrasound-guided venous cannulation

INTRODUCTION

Cannulation of a large central vein is the standard clinical method for monitoring central venous pressure and is also performed for a number of therapeutic interventions, such as providing secure vascular access for the administration of vasoactive drugs or to initiate rapid fluid resuscitation.[1]

The practice of using surface anatomy and palpation to identify target vessels before cannulation attempts (landmark technique) is based on the presumed location of the vessel, the identification of surface or skin anatomic landmarks, and blind insertion of the needle until blood is aspirated. Confirmation of successful cannulation of the intended vascular structure relies on blood aspiration of a certain character and color (lack of pulsation and dark color when cannulating a vein or pulsation and a bright red color when cannulating an artery), pressure measurement with a fluid column or pressure transducer, or observation of
the intraluminal pressure waveform on a monitor. Although frequently performed and an inherent part of medical training and practice, the insertion of vascular catheters is not free of complications. Depending on the site and patient population, landmark techniques for vascular cannulation are associated with a 60–95% success rate. The complications may occur more often with less experienced operators, challenging patient anatomy (obesity, cachexia, distorted, tortuous or thrombosed vascular anatomy, congenital anomalies such as persistent left superior vena cava), compromised procedural settings (mechanical ventilation or emergency), and the presence of comorbidity (coagulopathy, emphysema). Central venous catheterization-related mechanical complications include arterial puncture, hematoma, hemothorax, pneumothorax, arterial-venous fistula, venous air embolism, nerve injury, thoracic duct injury (left sided cannulation), intraluminal dissection, and puncture of the aorta.[6]

Ultrasonography (USG) provides “real-time” imaging, i.e., the needle can be visualized entering the vein. This reduces the chances of complications. Another advantage that USG cannulation offers is the visualization of vessels in hypotensive patients in whom carotid artery is difficult to palpate for landmark identification.[3]

Studies designed to evaluate the differences between USG-guided and landmark-guided techniques for central venous access have preferentially used the short-axis (SA) technique as the preferred approach for cannulation. Whereas the long-axis (LA) approach to vessel access also has been used successfully, we could find no studies designed to evaluate the differences between the two techniques. Previous studies have evaluated venous access through the use of the distal femoral vein using USG guidance, but again, the SA approach was employed. Despite the fact that two very different techniques exist for vessel visualization, one approach appears to predominate in US-guided central venous access. The SA approach attempts to view the vessel in cross-section while venous access is obtained. In contrast, the LA approach employs a technique that views the whole length of the vessel during cannulation.[4]

This study aims to compare between the LA and SA technique in terms of number of skin punctures, number of needle redirections, time required for insertion of guidewire, success of cannulation, and any complications. In addition, as a secondary analysis, the study aims to evaluate the relationship between diameter of internal jugular (IJ) vein and margin of safety with number of skin puncture, first pass success, and carotid puncture.

**SUBJECTS AND METHODS**

Ethical approval was obtained from Institution Review Board of the Institute. Adult subjects presenting for elective surgery or in Intensive Care Unit were enrolled in the study after obtaining a written informed consent. Patients with a short neck, uncooperative patients, pediatric patients (age <15 years), patients with vessel diameter <7 mm or with significant coagulopathy (International Normalized Ratio >1.5 or platelet count <50,000/cumm) are excluded from the study.

Sample size was calculated considering the first pass success results from the study by Chittoodan et al.[5] The sample size of 41 per group is calculated with 80% power and 5% significance level using G*Power 3.1 software (Franz Faul, Uni Kiel, Germany).[6] Patients were randomized by computer generated random number tables, to one of the two groups. Patients in Group A underwent cannulation with LA ultrasound-guided approach and patients in Group B underwent cannulation with SA approach. All patients had central venous cannulation of the IJ performed using the Seldinger technique.

Subjects were placed in a head-down position with the head turned slightly to the side, opposite to that of cannulation. The skin of the anterior and lateral neck was prepared using antiseptic solution and draped. The ultrasound probe was used as a 6–10 L38 MHz linear transducer SonoSite turbo unit (SonoSite®, Micromaxx, Bothwell, WA, USA). The probe was covered with a sterile sheath, and sterile ultrasound gel was applied to the inside of the sheath. Each cannulation was performed by an anesthesiologist with a minimum of 3 years of experience in cannulation of central veins. An observer unaware of the group allocation observed the procedure and recorded the following information: Cannulation success, number of skin punctures, number of needle redirections, time required for insertion of guidewire (time from first needle insertion to ultrasound confirmation of presence of the guidewire within the vein), and complications if any (carotid puncture or pneumothorax).

First pass success was defined as a procedure with single skin puncture and no needle redirections. The
margin of safety was the distance between the midpoint of IJV and the lateral border of the carotid artery. The diameter of IJV and margin of safety was measured at the same level and in the same head position of the patient as during cannulation.

**Long-axis technique**
An SA view of both IJ vein and carotid artery was obtained [Figure 1]. The probe was centered on the IJ vein and rotated through 90° in a clockwise direction resulting in an LA image of the vein. The needle insertion point was directly beneath the most proximal end of the ultrasound probe. The needle was inserted at 30° to the vertical and advanced toward the vein employing gentle aspiration. Entry to the vein was confirmed by visualizing needle entry into the vein followed by aspiration of blood in the syringe. Guidewire was inserted. Confirmation of guidewire placement was performed by scanning the vein in both SA [Figure 2] and LA [Figure 3].

**Short-axis technique**
An SA image of the IJ vein was obtained by placing the transducer in a transverse orientation on the patient’s neck at the level of the cricoid cartilage. The needle was inserted at 60° to the vertical and advanced toward the vein employing gentle aspiration on the attached syringe. Entry to the vein was confirmed by visualizing indentation of the anterior wall of the vein followed by blood in the syringe and by visualizing the tip of the needle inside the vein. Confirmation of guidewire placement in the IJ was performed by scanning the vein in both SA [Figure 2] and LA [Figure 3] planes.

**Statistical analysis**
Independent t-test and Chi-square test were used for performing the analysis. Pearson test was applied to calculate the strength of correlation.

**RESULTS**

Patients’ characteristics and clinical data are summarized in Tables 1-3. Values are mean (standard deviation) or absolute numbers.

There are significant differences between the two groups in terms of age. There were no significant differences between the two groups in terms of gender, diameter of IJ vein, margin of safety, and time required for insertion of guidewire. There was also no significant difference between the two groups in terms of side of IJV cannulated, patient on mechanical ventilation, number of skin puncture, number of needle redirections, first pass success, and carotid puncture.

However, there is a significant relationship between the diameter of IJV with first pass success (18.18 ± 4.72 vs. 15.21 ± 4.24; \( P = 0.004 \)) and
vein can be simultaneously viewed and minimal probe adjustment is required. However, during cannulation, the needle may not be seen as it is advanced out of the scanning plane. Therefore, needle tip location is based on visualization of tissue movement and educated guess work. With the LA view, however, the operator advances the needle in the LA of the scanning beam and can visualize the entire length of the needle as it punctures the target vessel. Although needle visualization is improved, the acquisition of the LA image of the IJ vein is technically more difficult than the SA view. Using the LA view, information regarding the location of the carotid artery relative to the IJ vein may be lost. Therefore, correct identification of the single vessel in the scanning field is essential. 

Our study compared the LA approach to SA approach for IJ vein cannulation for patients scheduled for surgeries and those in intensive care unit. We found that there were no significant differences between the two groups in terms of gender, diameter of IJ vein, margin of safety, and time required for insertion of guidewire. There was also no significant difference between the two groups in terms of side of IJ vein, patient on mechanical ventilator, number of skin puncture, number of needle redirections, first pass success, and carotid puncture. Tammam et al. also suggested suggest that the SA and LA approaches were comparable for cannulation of IJ vein in critical care and hemodialysis patients. However, Blaivas et al. concluded that novice ultrasound users obtain vascular access faster with an SA approach on an inanimate model.

### Table 1: Demographics and clinical characteristics

| Variables                                | Long axis | Short axis | P   |
|------------------------------------------|-----------|------------|-----|
| Age (years)                              | 49.59 (18.58) | 59.68 (22.01) | 0.028 |
| Diameter of internal jugular vein (mm)   | 17.78 (4.82) | 16.12 (4.56) | 0.113 |
| Margin of safety (mm)                    | 7.08 (2.99) | 6.37 (3.48) | 0.321 |
| Time required for insertion of guidewire(s) | 40.39 (22.83) | 45.24 (26.74) | 0.379 |

### Table 2: Demographics and clinical characteristics

| Variables                                | Long axis (%) | Short axis (%) | P   |
|------------------------------------------|---------------|---------------|-----|
| Sex                                       |               |               |     |
| Female                                   | 11 (26.8)     | 18 (43.9)     | 0.0106 |
| Male                                      | 30 (73.2)     | 23 (56.1)     |      |
| Side of internal jugular vein cannulation |               |               |     |
| Left                                     | 6 (14.6)      | 3 (7.3)       | 0.48 |
| Right                                    | 35 (85.4)     | 38 (92.7)     |      |
| Number of skin punctures                 |               |               |     |
| 1                                        | 38 (92.7)     | 37 (90.2)     | 1    |
| 2                                        | 3 (7.3)       | 4 (9.8)       |      |
| Number of needle redirections            |               |               |     |
| 0 or 1                                   | 27 (65.9)     | 21 (51.2)     | 0.381 |
| 1                                        | 9 (22.0)      | 14 (34.1)     |      |
| 2 or 3                                   | 5 (12.2)      | 6 (14.6)      |      |
| Patient mechanically ventilated          |               |               |     |
| No                                       | 18 (43.9)     | 25 (61.0)     | 0.122 |
| Yes                                      | 23 (56.1)     | 16 (39.0)     |      |
| First pass success                       |               |               |     |
| No                                       | 14 (34.1)     | 20 (48.8)     | 0.179 |
| Yes                                      | 27 (67.9)     | 21 (51.2)     |      |
| Carotid puncture                         |               |               |     |
| No                                       | 40 (97.6)     | 40 (97.6)     | 1    |
| Yes                                      | 1 (2.4)       | 1 (2.4)       |      |

### Table 3: Clinical characteristics

| Variables                                | Number of skin punctures | Mean (SD) | P   |
|------------------------------------------|--------------------------|-----------|-----|
| Diameter of IJ vein                      | 1                        | 17.25 (4.72) | 0.055 |
| Margin of safety                         | 2                        | 13.67 (3.83) | 0.474 |
| First pass success                       | 1                        | 6.65 (3.10)  |      |
| Carotid puncture                         | No                       | 7.57 (4.71)  |      |
| Diameter of IJ vein                      | Yes                      | 18.18 (4.72) | 0.004 |
| Margin of safety                         | No                       | 15.21 (4.24) |      |
| Carotid puncture                         | Yes                      | 6.24 (2.58)  | 0.133 |
| Carotid puncture                         | No                       | 7.41 (3.93)  |      |

IJ: Internal jugular, SD: Standard deviation

there is also a significant relationship between margin of safety with the incidence of carotid puncture (12.15 ± 4.03 vs. 6.59 ± 3.13; P = 0.016).

**DISCUSSION**

IJ cannulation can be aided by the use of real-time USG. While using ultrasound, two approaches can be undertaken: SA-needle (out-of-plane) or LA (in-plane); both approaches with its inherent advantages and disadvantages. In the SA approach, both the artery and vein can be simultaneously viewed and minimal probe adjustment is required. However, during cannulation, the needle may not be seen as it is advanced out of the scanning plane. Therefore, needle tip location is based on visualization of tissue movement and educated guess work. With the LA view, however, the operator advances the needle in the LA of the scanning beam and can visualize the entire length of the needle as it punctures the target vessel. Although needle visualization is improved, the acquisition of the LA image of the IJ vein is technically more difficult than the SA view. Using the LA view, information regarding the location of the carotid artery relative to the IJ vein may be lost. Therefore, correct identification of the single vessel in the scanning field is essential.

Our study compared the LA approach to SA approach for IJ vein cannulation for patients scheduled for surgeries and those in intensive care unit. We found that there were no significant differences between the two groups in terms of gender, diameter of IJ vein, margin of safety, and time required for insertion of guidewire. There was also no significant difference between the two groups in terms of side of IJ vein, patient on mechanical ventilator, number of skin puncture, number of needle redirections, first pass success, and carotid puncture. Tammam et al. also suggested suggest that the SA and LA approaches were comparable for cannulation of IJ vein in critical care and hemodialysis patients. However, Blaivas et al. concluded that novice ultrasound users obtain vascular access faster with an SA approach on an inanimate model.
We also analyzed the relationship between the vessel diameter and margin of safety in terms of number of skin punctures, first pass, and carotid puncture as the secondary analysis of our study. We found significant relationships between the diameter of IJ vein with first pass and margin of safety with of carotid puncture. The findings are similar to those observed by Sibai et al.[8] However, we would like to suggest further studies to consolidate these secondary findings. Real-time USG guidance improves success rates, reduces the number of attempts, and decreases the complications associated with central venous cannulation, especially for the IJ vein, and should be considered the standard of care in intensive care and anesthesia practice.[9]

This study, however, has several limitations. Although the observer who documented various findings during the central venous cannulation were unaware of the group allocation, most of them could guess the group allocation (SA vs. LA) observing the probe orientation. The phase of the respiratory cycle (inspiration or expiration) during the puncture of IJ vein, was not noted. Age of the patients in the two groups was not comparable.

CONCLUSION

To conclude, the LA and SA techniques for ultrasound-guided cannulation of IJ vein are comparable in terms of number of skin puncture, number of needle redirections, first pass success, and carotid puncture.

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Conflicts of interest
There are no conflicts of interest.

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