

CLINICAL INVESTIGATION

Randomized comparison of three transducer orientation approaches for ultrasound guided internal jugular venous cannulation

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Abstract

Background: Ultrasound-guided internal jugular venous access increases the rate of successful cannulation and reduces the incidence of complications, compared with the landmark technique. Three transducer orientation approaches have been proposed for this procedure: short-axis (SAX), long-axis (LAX) and oblique-axis (OAX). Our goal was to assess and compare the performance of these approaches.

Methods: A prospective randomized clinical trial was conducted in one teaching hospital. Patients aged 18 yr or above, who were undergoing ultrasound-guided internal jugular cannulation, were randomly assigned to one of three intervention groups: SAX, LAX and OAX group. The main outcome measure was successful cannulation on first needle pass. Incidence of mechanical complications was also registered. Restricted randomization was computer-generated.

Results: In total, 220 patients were analysed (SAX $n=73$, LAX $n=75$, OAX $n=72$). Cannulation was successful on first needle pass in 51 (69.9%) SAX patients, 39 (52%) LAX patients and 53 (73.6%) OAX patients. First needle pass failure was higher in the LAX group than in the OAX group (adjusted OR 3.7, 95% CI 1.71–8.0, $P=0.002$). A higher mechanical complication rate was observed in the SAX group (15.1%) than in the OAX (6.9%) and LAX (4%) groups ($P=0.047$).

Conclusions: As OAX showed a higher first needle pass success rate than LAX and a lower mechanical complications rate than SAX, we recommend it as the standard approach when performing ultrasound-guided internal jugular venous access. Further clinical studies are needed to confirm this conclusion.

Clinical trial registration: NCT 01966354

Key words: catheterization, central venous; clinical trial; jugular veins; ultrasonography, interventional

Internal jugular venous cannulation (IJVC) is commonly performed in the operating room and critical care settings. The traditional approach to IJVC is based on anatomical landmarks, but

current evidence-based recommendations state that ultrasound should be used whenever possible to guide this procedure.^{1–3} This increases the success rate, reduces the time and number

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Editor's key points

- Several approaches to cannulation of the internal jugular vein have been described.
- This study compared three ultrasound guided approaches to internal jugular venous cannulation in experienced operators.
- Ultrasound guidance using an oblique-axis approach was associated with higher success rate and fewer complications than short or long axis approaches.
- Further studies are required to confirm these findings.

of attempts until successful cannulation and reduces the incidence of mechanical complications when compared with the traditional landmark technique.⁴⁻⁵ Although ultrasound scanning of the targeted vessel before performing needle insertion without ultrasound control (ultrasound assistance) may be helpful,⁵ real-time ultrasound control of the needle tip during the actual vascular puncture (ultrasound guidance) is the gold standard of practice.¹⁻²

Different imaging approaches have been described.⁶⁻⁸ The short-axis approach (SAX) allows simultaneous visualization of both artery and vein, but can make needle tip control difficult.⁹⁻¹⁰ The long-axis approach (LAX) can optimize needle visualization, but it can be challenging to perform owing to certain anatomical limitations (such as neck length). Additionally, LAX only displays the vein in the ultrasound image (unless the artery lies directly underneath) and if the operator strays medially, accidental arterial cannulation can occur.⁹

The oblique-axis approach (OAX) tries to take advantage of the strengths of both previous approaches using a probe alignment that is midway between SAX and LAX, and combines it with an in-plane needle insertion in which the needle is advanced from lateral to medial.⁶ Thus, the OAX optimizes visualization of both the needle and the jugular vein with all its surrounding structures.

The purpose of the present study was to assess and compare the performance of these approaches (SAX, LAX and OAX) in terms of cannulation success and incidence of complications. Our primary hypothesis was that OAX was a better approach than SAX or LAX.

Methods

This study was designed as a prospective randomized controlled trial and included patients who underwent IJVC at the Navarra Hospital Complex, Pamplona, Spain. It was approved by the Ethical Committee for Clinical Investigations, Navarra Health Department (project number 95/11), and was registered with ClinicalTrials.gov (NCT01966354). Written informed consent was obtained from all participants before they were included in the study.

The day before IJVC was to be performed, patients (aged 18 or above) in whom IJVC had been indicated were asked to participate in the study. Patients who did not meet any exclusion criteria (as listed in Table 1) were included.

All the cannulations were performed by three anaesthetists with appropriate proficiency in ultrasound-guided central venous access. All of them underwent a structured training programme that included a two-hour lecture, a one-hour bedside teaching session on identifying the internal jugular vein and its surrounding structures using SAX, LAX and OAX, and a one-hour supervised puncture practice session using an ultrasound phantom in which in-plane and out-of-plane needle insertion techniques were reviewed. For all practical sessions an S-Nerve

Table 1 Patient exclusion criteria

- Age <18 yr
- History of previous surgical intervention at the cannulation site
- Presence of a central venous catheter during the past 72 h (in the same vein in which the present cannulation was planned)
- Infection signs or subcutaneous haematoma close to the puncture site
- Recent cervical trauma with present neck immobilization
- Analytical data suggesting severely altered haemostasis (INR >2, platelet count <50.000)
- Subcutaneous emphysema with cervical extension
- Agitated or uncooperative patient
- Cannulation planned to be performed outside of the surgical area
- Cannulation indicated during emergency surgery or immediately before it

ultrasound machine (SonoSite, Bothell, WA) with a 13–6 MHz 38-mm linear array probe was used - the same equipment that was used on the study subjects. Additionally, investigators were required to have performed at least ten successful supervised ultrasound-guided IJVC procedures, using each of the three approaches (LAX, SAX and OAX) before participating in the study, to ensure their proficiency with all of them.¹¹

Restricted randomization was performed using a random number list that had been computer-generated for each cannulator before the study commenced. Patients were randomly assigned (1:1:1) to have their cannulation performed SAX, LAX or OAX.

Every IJVC took place in the operating room or in the post-anaesthesia care unit. Patients were placed in a supine position. Standard monitoring (ECG, non-invasive arterial pressure, pulse oximetry) was carried out during the procedure for all patients, and supplementary oxygen was delivered via a nasal cannula in awake patients. Before preparation of the skin, a pre-procedural ultrasound exam was performed to verify internal jugular vein patency, and its diameter was measured.

Once the side had been chosen, the cannulation was performed following a sterile technique. Lidocaine 2% was used to anaesthetize the puncture site in awake patients. All the procedures were performed by a modified Seldinger technique, using a 18-Ga, 6.5 cm introducer needle (Arrow International, Reading, PA) with a 5 ml syringe attached to it. The vascular puncture was performed under ultrasound guidance, using a single-person technique (with the same operator handling the transducer and the needle). With SAX, the transducer was placed transversally over the neck (parallel to the clavicle), and once the vein was visible in the middle of the ultrasound image the needle was introduced in a plane perpendicular to the long axis of the transducer (Fig. 1A). With LAX, the transducer was placed longitudinally over the neck, and once the vein was identified the needle was inserted just underneath the footprint of the probe following its long axis from cranial to caudal (Fig. 1B). With OAX, the operator first obtained a short-axis view of the vein and then rotated the transducer to a position midway between the SAX and LAX views, inserting the needle just underneath the footprint of the probe, following its long axis from lateral to medial (Fig. 1C). Video recordings of the standardized

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