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Three-step method for ultrasound-guided central vein catheterization

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Editor's key points

- The long-axis, in-plane (LAX-IP) approach has advantages and disadvantages when performing ultrasound-guided central venous catheterization.
- This study reports a new three-step technique to overcome some of the potential problems of the LAX-IP approach.
- After operator training, the new technique was used in 100 patients.
- No major complications occurred, but some difficulties were reported.

Background. The long-axis view and in-plane needle approach (LAX-IP) for ultrasound-guided central vein catheterization is considered ideal because of the quality of real-time imaging. We describe a novel technique, using a step-by-step procedure, to overcome the pitfalls associated with the LAX-IP. This study was undertaken to demonstrate the clinical utility of this approach.

Methods. All operators underwent training before participation in this study. One hundred patients were enrolled in this study and underwent central venous catheterization using this method. Using a portable ultrasound and vein catheterization kit, patients were appropriately positioned and a straight portion of the vein identified (Step 1). A needle guide was used (Step 2) and the vein imaged in real time in two directions (Step 3), to identify the true long axis and prevent damage to surrounding tissues.

Results. The overall success rate for catheterization was 100% with a median of one puncture for each patient. All catheterizations were performed within three punctures. Problems with the first puncture included difficult insertion of the guide-wire due to coiling, difficult anterior wall puncture, less experience with the procedure, and other reasons. There were no complications associated with the procedure.

Conclusions. This three-step method is not dependent on an operator's ability to proceed based on spatial awareness, but rather depends on logic. This method can prevent difficulties associated with a two-dimensional ultrasound view, and may be a safer technique compared with others. Further clinical trials are needed to establish the safety of this technique.

Keywords: axillary veins; central venous catheterization; central venous pressure; jugular veins; subclavian veins; ultrasonography

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When ultrasound imaging is used to guide central venous catheterization, the image formed by the sonographic beam can be along the axis of the vein (long-axis view) or perpendicular to it (short-axis view). The long-axis view of the vessel and in-plane needle approach (LAX-IP)[1] for ultrasound-guided central vein catheterization is performed in real time, which allows imaging of the needle and vein during the entire procedure. This benefit of the LAX-IP is ideal compared with the short-axis view of the vessel and out-of-plane needle approach (SAX-OOP). However, the LAX-IP has some pitfalls, which may lead to unanticipated injury of surrounding structures or failure to place to the catheter (Fig. 1). We describe a novel technique to prevent the pitfalls associated with the LAX-IP and show its clinical efficacy in a pilot study.

The LAX-IP has three problems that must be overcome to be more clinically useful. First, a vein that is not straight is difficult to approach using this approach. Secondly, manoeuvring a needle under the guidance of a thin ultrasound beam requires specific training and skill. The situation may be complicated by the 'side-lobe' artifact. If the needle is slightly out of the plane of the ultrasound beam, the artifact makes the needle appear to be in the plane of the sonographic beam.[2] Thirdly, it is difficult to accurately identify the true centre of the vein on the longitudinal view. A similar image can be seen with the ultrasound beam glancing near the edge of the vein. If the direction of the longitudinal view is towards the sidewall of the vein, the needle tip may go through the wall of the vein. In a typical clinical setting, a combination

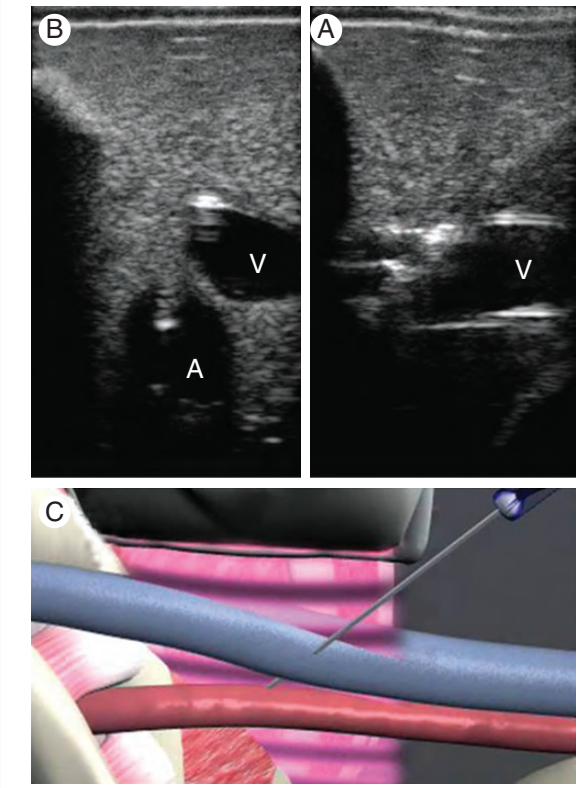

Fig 1 Pitfalls of the LAX-IP technique. Pitfalls associated with the LAX-IP are demonstrated using a simulator. V, vein; A, artery. (A) The longitudinal view shows what appears to be a correct orientation. (B) Actually, the tip of the needle is in the artery. (C) The three-dimensional graphic illustrates that the needle went through the vein into the artery.

of these problems can lead to misjudging, loss of the view of the needle on the ultrasound, or both, which could lead to failure of placement or unanticipated injury of surrounding structures. Each of these three problems can be overcome by applying this novel three-step method.

Methods

Ultrasound-guided central vein catheterization

(Step 1) Finding a straight portion of the target vein

A straight portion of the vein is selected for the puncture site, by precise and careful observation using the ultrasound transverse view. A straight portion is easily identified for the internal jugular vein. For a straight segment of the infra-clavicular axillary vein,[3 4] Sandhu[5] recommends straightening the vein by abduction of the patient's ipsilateral upper arm.

(Step 2) Using a needle guide

A needle guide is used, which decreases the training required for appropriate handling of the needle, and also prevents the 'side-lobe' artifact.

(Step 3) Set an ultrasound view along the true axis

Two scan techniques are applied to determine the true location of the long axis of the vein so that the puncture site will be in the centre of the vein.

Side-scape scan technique

Although the centre of the long axis is difficult to see on ultrasound, a view across the sidewall of the vein can be easily shown not to be the actual long axis. Since the centre of the vein is at the same distance from both sidewalls of the vein, the ultrasound probe is set furthest from both sidewalls of the vein using this logic. The procedure in detail is as follows:

(1) Stabilize the proximal edge of the probe by pinching the needle-guide wing with the right first and second fingers, while holding the distal edge of the probe with the left hand.
(2) Turn the distal edge of the probe to the right until the right sidewall of the vein is seen. Then, turn the distal edge to the left until the left sidewall of the vein is imaged.
(3) Repeat the scan (termed the 'side-scape scan'). Then, place the distal edge of the probe at the midpoint equidistant from both sidewalls of the vein.
(4) Do the same scan (1)–(3) at the proximal edge of the probe, by stabilizing the distal edge pinching with the left fingers.
(5) Finally, let both edges of the probe be placed equidistant from both sidewalls of the vein. This places the probe on a line just above the true long axis of the vein (Fig. 2).

Side-swing scan technique

One advantage of the long-axis approach is that venepuncture is performed with real-time imaging. Careful puncture may prevent puncture of the posterior wall of the vein, the so-called 'double wall puncture'. However, a large-bore needle and/or performing this in a patient with low venous pressure may lead to an unintended double wall puncture. Therefore, the ultrasound view is used to direct the needle away from surrounding structures, such as the artery, lung, or nerve, which are in close proximity to the vein (Fig. 3). The procedure in detail is as follows:

(1) Under ultrasound view, lower the probe to the right side on the skin and observe carefully whether any important structure is present.
(2) Then, lower the probe to the left side, checking carefully for important structures nearby.
(3) Repeat the same scan on both sides and set the probe so as not to be over an artery and/or lung on the ultrasound view.

By using a combination of the two techniques, the ultrasound view determines a safe direction without perforation