Should Real-Time Ultrasound Guidance Be Routinely Used for Central Venous Catheter Placement?

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James Leonard

Case

A cardiac anesthesia fellow on his first day had just intubated a 67-year-old male undergoing an on-pump 2-vessel coronary artery bypass grafting. The patient had a history of peripheral vascular disease, type 2 diabetes, hypertension, and recent non–ST-segment elevation myocardial infarction (NSTEMI). The fellow had just finished positioning and prepping the patient for a right internal jugular central venous catheter (CVC) placement when his attending walked back into the room and noticed the ultrasound equipment next to the patient's head.

"Wait a second, why do you have this in the room?" the attending asked.

"Ultrasound-guided central line placement was done by everyone at the residency program I was trained at," the fellow replied.

"I've been placing central lines for 30 years, have never used ultrasound, and have never had a complication. If you know your landmarks, you should be able to insert the catheter successfully every time without the use of ultrasound."

Question

Should real-time ultrasound guidance be routinely used for central venous catheter placement?

PRO: The overwhelming majority of central venous catheters (CVCs) are placed in 1 of 3 locations: the internal jugular (IJ), subclavian, or femoral veins using either the landmark technique or the real-time ultrasound-guided technique.

J. Leonard (✉)
Department of Anesthesiology, Perioperative Care and Pain Medicine, New York University Langone Medical Center, 550 First Avenue, New York, NY 10016, USA
e-mail: james.leonard@nyumc.org

While there are many techniques utilizing landmarks for IJ cannulation, the most commonly described method relies on directing the needle between the medial and lateral heads of the sternocleidomastoid muscle, lateral to the carotid artery, and advancing the needle toward the ipsilateral nipple in order to cannulate the vein. For subclavian vein cannulation, the patient is positioned in Trendelenburg, the shoulders are extended, and the needle is inserted 1 cm lateral to the middle third of the clavicle. The needle is walked under the clavicle, directed toward the sternal notch, and slowly advanced until cannulation occurs. For femoral vein cannulation, the femoral artery is palpated and the needle is directed medially to the arterial pulsation 1–2 cm below the inguinal ligament until cannulation occurs.

Ultrasound-guided techniques have been described for IJ, subclavian, and femoral vein CVC placement. Based upon available evidence, ultrasound guidance for IJ CVC placement is the most strongly supported of the 3 sites. Meta-analyses of randomized trials including both adults and infants demonstrated the following benefits of ultrasound guidance versus the landmark technique: a significantly higher rate of successful placement in both adults and infants (99 versus 78 %), a reduction in failed IJ cannulation on the first attempt (33 versus 57 %), fewer total numbers of attempts in adults and infants (1.5–2 fewer mean needle passes), and a reduction in complications, including arterial puncture, in both adults and infants (from 16 to 5 % and from 30 to 6 %, respectively) [1, 2].

CON: The cardiac anesthesia attending allowed the fellow to proceed with ultrasound-guided right IJ CVC placement. Upon ultrasound examination of the right IJ vein, significant intravascular clot was found. Examination of the left IJ revealed a similar level of clot.

"We should attempt a right subclavian line placement," the attending remarked to the fellow. "Should we use ultrasound for that as well?".

Evidence in support of ultrasound guidance is decidedly less robust for femoral and subclavian CVC placement

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compared to IJ placement. With regard to femoral vein cannulation, 1 randomized controlled trial found a higher first-attempt success rate and fewer required needle passes with ultrasound guidance compared to the landmark technique in pediatric patients [3]. For subclavian vein cannulation, a randomized controlled trial of more than 400 mechanically ventilated patients in medical intensive care units reported fewer insertion attempts, higher success rates, reduced access time, and fewer arterial punctures and hematomas when using ultrasound guidance compared with the anatomic landmark approach [4].

PRO: The fellow was familiar with the available evidence regarding ultrasound use in subclavian vein cannulation and knew that his attending was testing his depth of knowledge.

"While I have less experience with ultrasound for subclavian vein CVC placement, I don't think you could be faulted for utilizing it. Overall, ultrasound is a safe technique, and there aren't any complications unique to ultrasound-guided vascular access compared to landmark-guided access that I'm aware of. If you feel comfortable with the technique, why wouldn't you use it?" the fellow replied.

CON: "You bring up something very important there," the attending noted. "The level of benefit of these ultrasound-guided techniques is probably highly operator-dependent."

Indeed, the attending may have a point. When discussing the relative strengths and weaknesses of their study on ultrasound-guided subclavian vein cannulation, Fragou and colleagues conceded that "the benefits of the ultrasound method may not accrue until after a significant learning period and its learning curve may be highly operator-dependent" [4]. This operator-dependent learning curve should therefore be taken into account when ultrasound-guided techniques are utilized.

The fellow and attending proceeded with successful landmark-guided right subclavian central line placement and noted an excellent venous waveform upon connecting the CVC to the transducer.

"Should we get a chest X-ray in the recovery room to confirm the position of the catheter?" the attending asked.

While radiographic confirmation of femoral vein CVC placement is not routinely performed, a variety of modalities have been described to confirm IJ or subclavian catheter placement. Manometry was found in a retrospective analysis to detect arterial punctures not identified by blood flow and color [5]. A randomized controlled trial showed that continuous electrocardiography is efficacious in identifying correct catheter tip placement compared with not using the technique [6]. Observational studies have noted that both fluoroscopy and chest radiography are beneficial in identifying the catheter tip's position after CVC placement. However, in cases where fluoroscopy has been used for catheter placement (such as in the IR suite), a post-procedure chest X-ray is unnecessary unless the suspicion for complications such as pneumothorax is high. More recently, investigators have questioned the need for routine post-procedure chest X-rays for uncomplicated right IJ catheters placed on the first attempt, as the incidence of complications and catheter malposition in this situation is very low [7].

Summary

The available evidence strongly supports the use of ultrasound guidance in IJ CVC placement. This recommendation is reinforced in the 2012 American Society of Anesthesiologists (ASA) Practice Guidelines on Central Venous Access [8], which also states that ultrasound guidance may be used when the subclavian or femoral vein is selected for cannulation. Furthermore, these guidelines recommend the use of waveform manometry or pressure measurement to confirm venous placement of the catheter prior to use. Methods for confirming proper catheter tip position include fluoroscopy, chest radiography, or continuous electrocardiography. While unnecessary when the catheter is placed under fluoroscopy, a post-procedure chest X-ray is still recommended to confirm correct intraoperative placement of IJ and subclavian CVCs, although recent studies have questioned the utility of routine postoperative chest X-rays for uncomplicated right IJ CVC insertions.

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