

Central venous catheter insertion and ultrasound guidance

Kelly Stowell, MSN, APRN, RNFA, FNP-C, AG/ACNP-BC

The clinical question

In adults who need a central venous catheter (CVC), does ultrasound guidance reduce complications and failed attempts compared with the anatomical landmark technique, and does the answer change with the insertion site?

Summary

Real-time ultrasound should be used for every internal jugular catheter. In a Cochrane review of 35 trials at the internal jugular site, two-dimensional ultrasound cut total complications by 71% and arterial puncture by 72%.⁶ The gains at the subclavian and femoral sites are smaller and come from low-quality trials. There, ultrasound lowered arterial puncture and hematoma at the subclavian vein and raised first-attempt success at the femoral vein, but it did not change total complications or insertion time.⁵ CDC guidance recommends ultrasound when it is available and the operator is trained, and it recommends avoiding the femoral vein in adults.³

Indications

Central access is indicated for fluids, electrolytes, antibiotics and concentrated medications that peripheral veins tolerate poorly. It is also used for hemodynamic monitoring, frequent blood sampling, parenteral nutrition, hemodialysis, transvenous pacing and pulmonary artery catheter placement.²

Contraindications

Coagulopathy and thrombocytopenia are relative contraindications, and a current StatPearls review reports clinically significant bleeding in about 0.8% of patients with coagulopathy. The review treats an INR above 3.0 or platelets below $20 \times 10^9/L$ as severe coagulopathy, where plasma or platelets may be considered around the procedure. Its absolute contraindications are active infection at the site, anatomic distortion from indwelling hardware and vascular injury near the site. It also advises against the subclavian site in coagulopathic patients because the vessels there cannot be compressed.¹

During consent, discuss the risks of infection, pneumothorax with internal jugular and subclavian approaches, dysrhythmia when the guidewire reaches the right atrium, arterial puncture, pseudoaneurysm, thrombosis and arteriovenous fistula.²

Technique

Common steps

Right-sided vessels are preferred because they take a more direct course to the right atrium.² For internal jugular and subclavian access, place the patient in Trendelenburg position to fill the vein and reduce the risk of air embolism. Use maximal sterile barrier precautions, which means a cap, mask, sterile gown, sterile gloves and a sterile full-body drape.³

The Seldinger technique starts with a 22-gauge seeker needle on a 5-mL syringe, followed along the same track by an introducer needle, typically 18 gauge. Advance slowly under continuous aspiration until dark, nonpulsatile blood confirms you are in the venous lumen. Then pass the guidewire, remove the needle, nick the skin and dilate the tract. Advance the catheter over the wire, remove the wire and confirm that every port aspirates and flushes. After internal jugular or subclavian placement, obtain a chest radiograph to confirm tip position and exclude pneumothorax.²

Internal jugular vein

Of the three approaches (central, posterior and anterior), the central approach is the most common. With the head turned slightly away, insert the needle at the apex of the triangle formed by the two heads of the sternocleidomastoid and the clavicle, about 5 cm above the clavicle and just lateral to the carotid pulse, at 30 to 45 degrees. Aim toward the ipsilateral nipple. The vein is usually entered within 2.5 cm. The right side is preferred for its larger caliber, the lower apex of the right lung and easier access for a right-handed operator.²

Subclavian vein

The vein is usually accessed near the midpoint of the clavicle by an infraclavicular or supraclavicular approach.² For the infraclavicular approach, enter about 1 cm lateral to the bend of the clavicle and 2 to 3 cm below it, keep the needle shallow enough to pass just beneath the clavicle and aim at the suprasternal notch. For the supraclavicular approach, enter 1 cm lateral to the lateral head of the sternocleidomastoid and 1 cm above the clavicle, and aim toward the contralateral nipple.

Femoral vein

The vein lies just below the inguinal ligament, halfway between the anterior superior iliac spine and the symphysis pubis, medial to the femoral artery. The mnemonic NAVEL orders the structures from lateral to medial as nerve, artery, vein, empty space and lymphatics.² Keep one hand on the femoral pulse and hold the needle at 30 to 40 degrees, bevel up. In a patient of average build the vein is

usually reached at 2 to 4 cm. Search medial to lateral in a systematic pattern, and if no blood returns, withdraw slowly, because the vein is often entered on the way out. Because of infection risk, CDC gives a Category IA recommendation to avoid the femoral vein for central access in adults, and for nontunneled catheters in adults it prefers the subclavian site over the jugular or femoral site to reduce infection.³

The evidence

Ballard 2014: what emergency physicians report

Ballard and colleagues ran a cross-sectional survey of all emergency physicians in a 21-hospital integrated health system in California. The system had just adopted an early goal-directed therapy protocol for severe sepsis and septic shock that included CVC when indicated, and it offered optional hands-on training in ultrasound-guided insertion.⁴

The response rate was 78% (365 of 465). Of respondents, 76% (271 of 358) were comfortable placing an internal jugular catheter with ultrasound, compared with 58% (200 of 345) placing a subclavian catheter without it. The most commonly reported barriers were complication risk (61%) and procedure time (56%). After multivariable adjustment, four factors were associated with higher yearly CVC volume: informal bedside training after residency, male sex, disagreement with complication-related barriers and comfort with ultrasound-guided internal jugular placement.⁴

The authors concluded that informal ultrasound training and sharing evidence on the low complication rate of the procedure could raise CVC rates in eligible patients. All responses were self-reported and came from one health system, and the survey measured attitudes and line volume rather than patient outcomes.

Brass 2015: subclavian and femoral sites

Brass and colleagues conducted a Cochrane systematic review of randomized and quasi-randomized trials comparing ultrasound or Doppler ultrasound with landmark technique for subclavian or femoral catheterization in adults and children. The search covered CENTRAL, MEDLINE, EMBASE and CINAHL. Thirteen studies met inclusion criteria, with 2,341 participants and 2,360 procedures.⁵

At the subclavian vein (9 studies, 2,030 participants), two-dimensional ultrasound reduced inadvertent arterial puncture (3 trials, 498 participants, RR 0.21, 95% CI 0.06 to 0.82) and hematoma (3 trials, 498 participants, RR 0.26, 95% CI 0.09 to 0.76). It did not change total complications, attempts to success, first-attempt success or insertion time. At the femoral vein (4 studies, 311 participants), ultrasound raised first-attempt success (3 trials, 224 participants, RR 1.73, 95% CI 1.34 to 2.22). The rise in total success was small and did not reach significance (RR 1.11, 95% CI 1.00 to 1.23, $P = .06$), and arterial puncture did not differ. No trial reported mortality.⁵

The authors rated the evidence very low to low for most outcomes, since most trials had unclear risk of bias and heterogeneity was significant. They concluded that ultrasound offers small gains in safety and quality at these two sites.⁵ The evidence is current only to January 2013, and as of October 2026 PubMed lists no later version of this review and the Cochrane summary reports no update or withdrawal.

Brass 2015: internal jugular site

The companion Cochrane review by the same group pooled 35 trials with 5,108 participants at the internal jugular vein. Two-dimensional ultrasound reduced total complications (14 trials, 2,406 participants, RR 0.29, 95% CI 0.17 to 0.52) and arterial puncture (22 trials, 4,388 participants, RR 0.28, 95% CI 0.18 to 0.44), and it raised first-attempt success by 57%. Evidence quality was very low for most outcomes and moderate at best for four.⁶

Study	Design	Population	Main finding
Ballard 2014 ⁴	Cross-sectional survey	365 emergency physicians, 21 hospitals	76% comfortable with ultrasound-guided IJ, 58% with landmark subclavian
Brass 2015, CD011447 ⁵	Cochrane systematic review, 13 RCTs	2,341 participants, subclavian or femoral	Fewer subclavian arterial punctures and hematomas, better femoral first-attempt success, no change in total complications
Brass 2015, CD006962 ⁶	Cochrane systematic review, 35 RCTs	5,108 participants, internal jugular	Total complications RR 0.29, arterial puncture RR 0.28

Implications for practice

The internal jugular evidence is strong enough to make ultrasound the default at that site, with a trial base more than twice as large as at the other two sites and a large effect on complications. At the subclavian and femoral sites ultrasound still reduced some harms and failed first passes, but total complications did not fall, and that more likely reflects thin data than a true absence of benefit. The Brass group could not test whether benefit differs between novice and experienced operators, so we do not yet know who gains most.

CDC prefers the subclavian site to reduce infection,³ but the strongest ultrasound evidence is at the internal jugular. Choosing a site means weighing infection risk against bleeding risk, and the operator's skill with the probe belongs in that decision.

In Ballard's survey, physicians who were comfortable with ultrasound-guided internal jugular insertion, and who had informal bedside training after residency, placed more lines.⁴ When I worked alongside surgical residents in 2015, ultrasound had already become the informal default for jugular access. The Cochrane results support that habit, and it should have formal training behind it.

Takeaways

- At the internal jugular vein, ultrasound cut total complications by 71% and arterial puncture by 72% across 35 trials.
- At the subclavian vein, ultrasound reduced arterial puncture (RR 0.21) and hematoma (RR 0.26). At the femoral vein, it improved first-attempt success (RR 1.73). Total complications did not change at either site.
- Coagulopathy is a relative contraindication, so choose a compressible site when bleeding risk is high.
- CDC recommends avoiding the femoral vein in adults (Category IA) and using ultrasound when the operator is trained (Category IB).

Recommendation

Use real-time ultrasound for every internal jugular catheter you place or supervise.

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