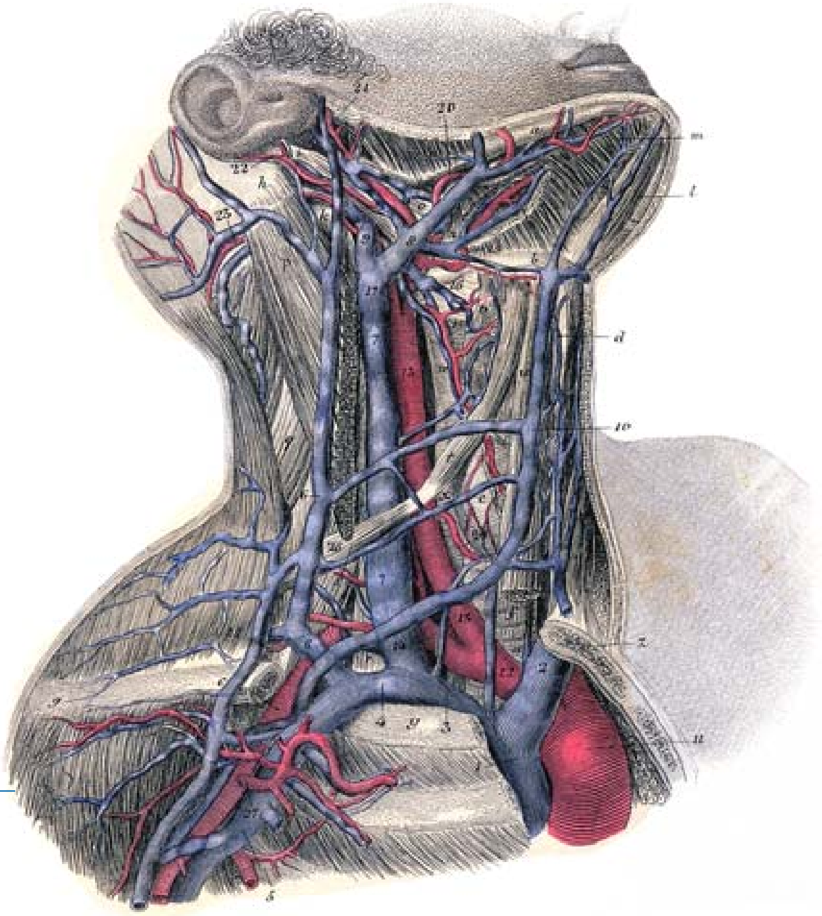
Ultrasound-Guided Central Vein Cannulation:

Current Recommendations and Guidelines



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Ultrasound technology has become an essential tool for the everyday practice of anesthesiology. Some of the many uses include the placement of central, arterial, and peripheral lines, as well as peripheral nerve blocks. Until recently, neither a national standard for ultrasound use nor a well-accepted standard in training for ultrasound-guided central venous cannulation (CVC) existed. In the past few years, several specialty societies and national organizations—including the American Society of Anesthesiologists, the American Society of Echocardiography, the Society of Cardiovascular Anesthesiologists, and the Centers for Disease Control and Prevention (CDC)—have published guidelines and recommendations regarding ultrasound-guided vascular cannulation.

Catheterization of venous vessels allows access for hemodynamic monitoring; administration of drugs, fluids, and parenteral nutrition; placement of a difficult peripheral IV; and hemodialysis. The internal jugular vein (IJV) and subclavian and femoral veins are the vessels of choice when acquiring central access. For many anesthesiologists, the IJV is a first choice. Historically, entry into the IJV has been facilitated by the visualization and palpation of certain anatomic landmarks. Additional techniques include the use of a smaller bore "finder needle" to first locate the IJV prior to cannulation with a larger bore needle; an indirect ultrasound method, in which the practitioner marks the path of the vein prior to cannulation; and a direct ultrasound technique, in which the vein is visualized using sonography during cannulation.[1]

The risk for complications during CVC is reported to be between 2% and 15%.[2] This rate varies significantly depending on several factors, including the experience of the practitioner and the overall status of the patient.[3,4] Among the more frequently encountered complications of CVC, and their respective incidences, are pneumothorax (0-6.6%), carotid artery puncture (6%), subclavian artery puncture (0.5%-4%), and hemothorax (1%).[1] In addition, the overall rate of unsuccessful central venous cannulation of the IJV is approximately 12%.[5]

Earlier studies showed that the use of ultrasound may increase the rate of success of central venous catheter placement and may reduce the incidence of traumatic complications.[6] More recent literature has confirmed that ultrasound guidance during insertion of a central venous catheter in the IJV improves the likelihood of first-pass cannulation and decreases the incidence of injury to adjacent arterial vessels.[7]

History

In 1978, Ullman and Stoelting described the first use of ultrasonography for accessing central veins. They used Doppler localization to mark the skin overlying the IJV. They reported that using an ultrasound Doppler blood-flow detector took the "guesswork" out of finding the vein and allowed them to locate the IJV as it traversed the neck. According to the authors, this new technique would increase the success rate of IJV catheterization and decrease accidental puncture of the carotid artery compared with the traditional technique using only anatomic landmarks.[8] In 1986, Yonei et al reported on the use of real-time ultrasonographic guidance for IJV cannulation.[9] In 2001, the Agency for Healthcare Research and Quality (AHRQ) reported that use of ultrasonography during central venous access deserved widespread implementation based on the strength of evidence in the literature.[10] The AHRQ recommended the use of ultrasound guidance for the placement of central lines as one of 11 evidence-based practices most likely to improve patient safety. In 2002, the National Institute for Clinical Excellence stated that ultrasound guidance was the preferred method for insertion of central venous catheters into the IJV, and recommended that all clinicians involved in placing these catheters receive appropriate training.[11]

In 2011, the CDC recommended use of ultrasound guidance to place central venous catheters to reduce the number of cannulation attempts and mechanical complications. Furthermore, in its publication, *Guidelines for the Prevention of Intravascular Catheter-Related Infections*, the CDC stated that ultrasound guidance should only be used by those clinicians fully trained in the technique.[12]

Static Versus Dynamic Imaging

Static, or indirect, ultrasound imaging during central venous access allows the operator to identify an entry point on the skin over the vessel prior to sterile preparation of the site. Anatomic variations and vital structures may be noted. Compared with the traditional anatomic landmark approach, use of static ultrasound for marking the skin site before cannulation of the IJV is more likely to result in a successful insertion into the vessel.[13] Dynamic, or direct, imaging during CVC allows for needle observation as the needle approaches the target vessel. In addition to being more likely to result in a successful insertion on the first attempt, real-time imaging during cannulation of the IJV also reduces access time and the rate of arterial puncture and has a higher overall success rate.[14-16]

Training

The evidence clearly indicates that the use of ultrasound imaging during central venous catheterization, particularly of the IJV, improves success and safety during cannulation. However, the technique also has a well-recognized learning curve. Knowledge of the anatomy of the vessels and surrounding structures is imperative. Interpreting 2-dimensional images of vessels and the surrounding structures takes practice. It takes more practice to perform the 3-dimensional task of placing a needle into the target vessel and developing the eye-hand coordination required to direct the probe to optimize visualization of the needle.

Although individuals acquire the necessary knowledge and skills at different rates, it has been suggested that a minimum of 10 ultrasound-guided vascular access procedures be supervised to demonstrate competency in the technique.[7] Kaye et al identified a "critical" number of central line insertions to differentiate the "experienced" ultrasound user from the novice. They found that anesthesiologists who had performed at least 20 central line insertions under ultrasound guidance had significantly fewer complications than inexperienced clinicians (Figure 1).[1]

Simulation has proven to be a beneficial training tool for developing proficiency in the use of ultrasound guidance for placing a CVC. Simulation-based ultrasound training results in improved identification of the target vessel with ultrasound compared with landmark techniques and helps inexperienced operators achieve higher rates of successful central line placement with an improved safety profile.[17,18] Studies looking specifically at simulation-based training and various outcomes of CVC support its use as a teaching method. These outcomes include successful first cannulation, fewer needle passes, successful catheter insertion, and fewer pneumothoraces.[19,20]

Site Selection

Recommendations regarding selection of a site for placing a line for central venous access involve considerations such as risk for infection, thrombosis, hematoma, pneumothorax, and arrhythmias. To minimize the risks for infection and thrombosis, insertion sites in the upper body, IJV, and subclavian vein are preferred to the femoral vein. The insertion site should be free of contamination or potential contamination. Sites in close proximity to wounds, burns, saliva, excrement, and infections should be avoided.

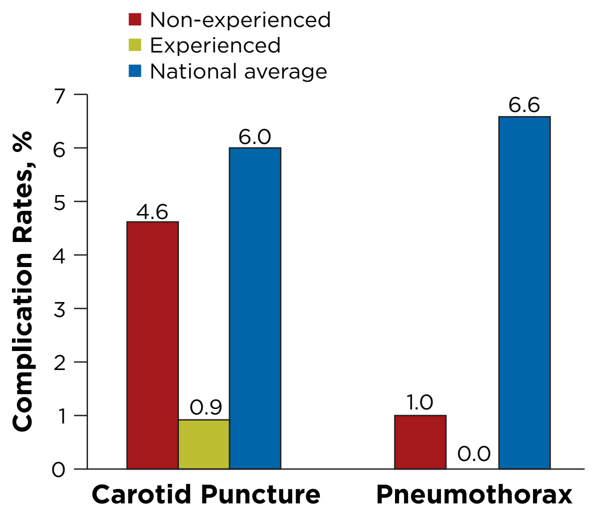

Figure 1. Complication rates of experienced versus non-experienced ultrasound practitioners.

National average represents blind technique. Experienced ultrasound practitioners had significantly reduced complication rates. Experienced practitioners were defined as those clinicians taught with ultrasound for central line insertion on a minimum of 20 different patients.[1]

The subclavian vein is the preferred site for longer-dwelling catheters because it has the lowest rate of infection and thrombosis. Although ultrasound guidance for insertion of a catheter in the IJV has overwhelming support in the literature, the use of ultrasound for cannulation of the subclavian vein is more complicated. The clavicle obscures visualization of the vessel, making dynamic imaging during cannulation difficult. However, patients in whom external landmarks are hard to identify, such as the morbidly obese or those who have local scarring from surgery or radiation in the neck, static ultrasound imaging prior to cannulation may help to visualize the vessel and rule out thrombosis.[7]

The femoral vein is a frequent site of catheterization during cardiac procedures, emergent central access, and other therapies that require short-term access to a vessel. Reliable anatomic landmarks and relatively quick and safe access are advantages of femoral vein cannulation. Ultrasound examination of the anatomy prior to cannulation reveals the location of the vessels and surrounding structures. However, real-time ultrasound imaging during femoral vein catheterization has not been shown to improve outcomes, and evidence currently does not support routine use of ultrasound imaging during this procedure.[7]

Confirmation of Location

Unintentional dilation of an artery during CVC is best avoided by confirming location of the guide wire prior to dilating the vessel. Real-time ultrasound guidance is a reliable way to determine if the wire sits in a vein.[22] The technology is particularly helpful for avoiding dilation of the carotid artery while attempting catheterization of the IJV (Figure 2). Ultrasound visualization of the guide wire in the longitudinal view, or long axis, of the vein is less ambiguous than the cross-sectional, or short axis, view by itself (Figures 3 and 4). Aligning the ultrasound probe to view the long axis of a central vein and the wire within takes less than a minute for most users and provides another safety measure to avoid arterial injury.[7] Manometry, transesophageal echocardiography, direct pressure transduction, analysis of blood gases, fluoroscopy, and electrocardiography also can help confirm the location of a wire in a vein.[23]

When available, these techniques provide a more definitive, although time-consuming, confirmation that the wire is in a central blood vessel. Confirmation of the correct location of the catheter tip following CVC requires chest radiography or fluoroscopy.

Removal of a catheter following inadvertent arterial cannulation carries risks for serious complications including stroke, hemothorax, and arteriovenous fistula. In this situation, the catheter should be left in place and a general or vascular surgeon should be consulted immediately for optimal removal.[24]

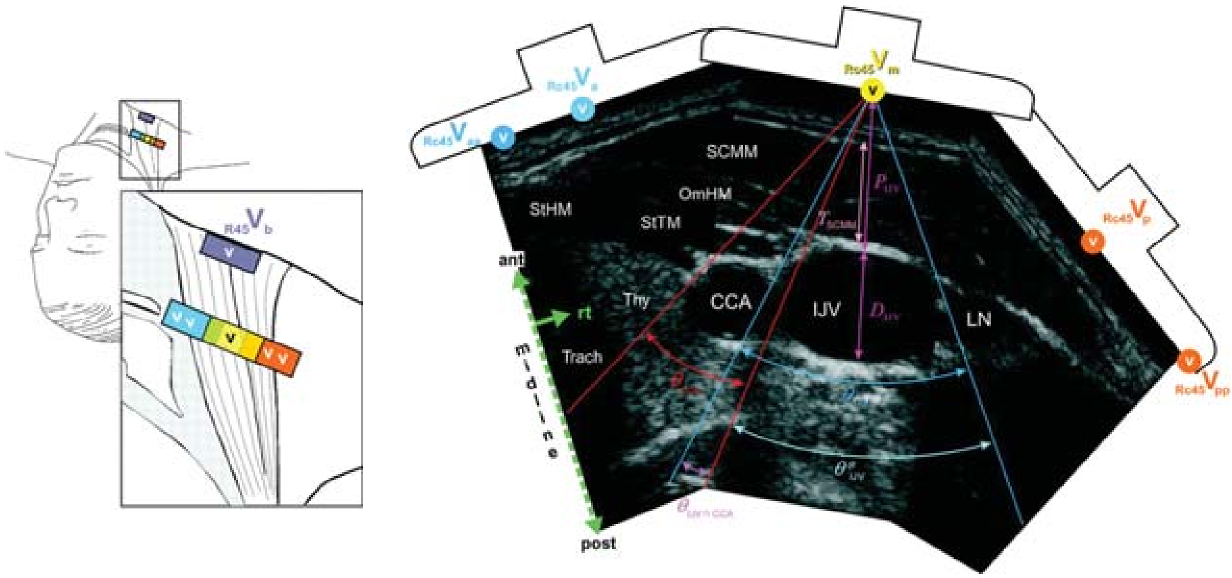

Figure 2. Cervical ultrasound anatomy relevant to internal jugular venipuncture.

Left. Operator's view of the 4 right-sided ultrasound probe positions; inset shows a magnified view of the region of the sternocleidomastoid triangle and the locations of the 6 right-sided cutaneous vantage points (Vs).
Right. Composite diagram of overlapping transverse ultrasonic images obtained from the 3 right-sided cricoid-level ultrasound probe positions of one subject (head rotated 45° to the left). Key to color coding of rectangles indicating standard ultrasound probe positionings: blue=high anterior; yellow=high middle; orange=high posterior; gray=low middle.

45, head rotated 45° away from the side of measurement; **a,** overlying the anterior (medial) portion of SCMM; **aa,** medial to SCMM; **ant,** anterior; **b,** base of neck; **c,** cricoid level; **CCA,** common carotid artery; **IJV,** internal jugular vein; **LN,** lymph node; **m,** overlying the mid portion of the SCMM (transverse plane) or between its sternal and clavicular heads; **OmHM,** omohyoid muscle; **p,** overlying the posterior (lateral) portion of the SCMM; **post,** posterior; **pp,** posterior to the SCMM; **R,** right side of neck; **rt,** right; **SCMM,** sternocleidomastoid muscle; **StHM,** sternohyoid muscle; **StTM,** sternothyroid muscle; **Thy,** thyroid gland; **Trach,** trachea.[21] Reprinted with permission.

Infection Control

Evidence-based recommendations for the prevention of bloodstream infections associated with central lines emphasize education and training of the health care providers inserting and maintaining the catheters, aseptic technique, maximum sterile barrier precautions during insertion, and use of an alcoholic formulation of chlorhexidine for skin disinfection and manipulation of the vascular line.[12] To prevent infection, routine placement of central venous catheters should be avoided. If such a catheter is necessary, an insertion site in the upper body should be considered first.

To minimize the risk for infection, insertion into the subclavian vein is preferable. Use of a bio-occlusive dressing is recommended, and only qualified personnel should be involved in the changing and care of the catheter.[12] Central venous catheters should be removed promptly when no longer necessary. In the event of a catheter-related infection, a new catheter should be placed at a new site rather than changing the catheter over a guide wire.[24] Use of ultrasound guidance for CVC has not been shown to increase the rate of catheter-related infections; no published study has noted this complication. Sterile needle guides and probe sleeves are widely available and should be used to maintain sterile technique during insertion of the catheter.

Cost and Implementation

Despite overwhelming evidence that the use of ultrasound guidance for CVC improves patient safety and clinical outcomes, the technology must be available to the practitioner. The typical cost of an ultrasound machine, including probes, is $20,000 to $30,000. Therefore, it is important to consider the potential cost savings associated with use of ultrasound for CVC. Ultrasound guidance for catheterization of the IJV consistently results in higher rates of successful cannulation, a lower incidence of complications and cannulation attempts, and a reduction in time spent trying to successfully place a catheter.[25] The estimated cost of a pneumothorax resulting from landmark-guided insertion of a central line is approximately $134 per patient. Based on a conservative estimate of 1.5 pneumothoraces per 100 patients using the landmark technique, this complication translates into $5 million to $10 million per year nationally in avoidable expenditures.[26]

Reductions in failure rates and number of attempts improve efficiency and help demonstrate the economic benefits of ultrasound. Furthermore, ultrasound guidance plays a role in other procedures. The technology has a clearly established role in the placement of peripheral nerve blocks and arterial lines.[27,28] Overall cost savings can be realized through a reduction in complications, improved efficiency of health care providers, and increased patient safety.

Future Directions

The possibility that ultrasound could create an unhealthy dependence on technology for future generations of anesthesiologists has been the subject of recent debate. It has been suggested that if ultrasound guidance becomes the standard of care for CVC, the anatomic landmark technique might be abandoned. As a consequence, practitioners would lose their skills and trainees would never acquire the ability to place a central line by anatomic landmarks alone. In the event that an ultrasound device is unavailable or not working properly, complications and decreased success rates might result. Advocates of the anatomic landmark technique argue that every anesthesiologist should be able to place a central venous catheter without ultrasound and still achieve a low incidence of complications and a high rate of success.[29]

Some authors have tried to reconcile the 2 seemingly opposing techniques, suggesting that training programs should teach the landmark technique alongside ultrasound guidance. But, is it realistic to require trainees to learn the landmark technique when it is unlikely they will use it enough to become skillful or even remain competent in the method?[30] Real-time ultrasound guidance has become standard practice for cannulation of the IJV and has an expanding role in securing other sites for vascular access. The importance of training in ultrasound guidance for CVC to achieve improved clinical outcomes has been demonstrated repeatedly. Training, therefore, would perhaps be better spent mastering the ultrasound guidance of CVC.[31]

Conclusion

Current literature supports the use of real-time ultrasound guidance for cannulation of the IJV whenever possible to improve success rates and reduce complications. Evidence also clearly indicates that proper training is necessary to achieve better clinical outcomes and improve patient safety.

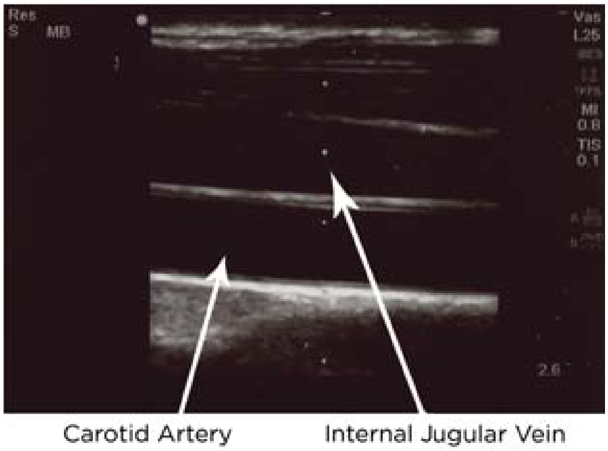

Figure 3. Long-axis view of internal jugular vein and carotid artery.

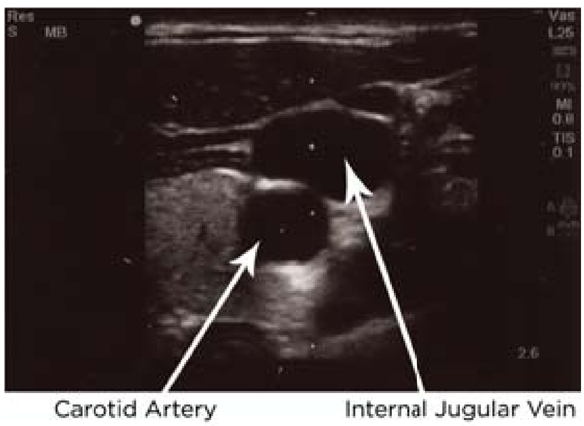

Figure 4. Short-axis view of internal jugular vein in close proximity to carotid artery.

References

1. Kaye AD, Fox CJ, Hymel BJ, et al. The importance of training for ultrasound guidance in central vein catheterization. *MEJ Anesthesiol*. 2011;21(1):61-66.
2. Domino KB, Bowdle TA, Posner KI, Spitellie PH, Lee LA, Cheney FW. Injuries and liability related to central vascular catheters: a closed claims analysis. *Anesthesiology*. 2004;100(6):1411-1418.
3. Bo-Linn GW, Anderson DJ, Anderson KC, McGoon MD. Percutaneous central venous catheterization performed by medical house officers: a prospective study. *Cathet Cardiovasc Diagn*. 1982;8(1):23-29.
4. Eisenhauer ED, Derveloy RJ, Hastings PR. Prospective evaluation of central venous pressure (CVP) catheters in a large city/county hospital. *Ann Surg*. 1982;196(5):560-564.
5. Denys BG, Uretsky BF, Reddy PS. Ultrasound-assisted cannulation of the internal jugular vein. A prospective comparison to the external landmark-guided technique. *Circulation*. 1993;87(5):1557-1562.
6. Ruesch S, Walder B, Tramèr MR. Complications of central venous catheters: internal jugular versus subclavian access—a systematic review. *Crit Care Med*. 2002;30(2):454-460.
7. Troianos CA, Hartman GS, Glas KE, et al. Guidelines for performing ultrasound guided vascular cannulation: recommendations of the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists. *J Am Soc Echocardiogr*. 2011;24(12):1291-1318.
8. Ullman JI, Stoelting RK. Internal jugular vein location with the ultrasound Doppler blood flow detector. *Anesth Analg*. 1978;57(1):118.
9. Yonei A, Nonoue T, Sari A. Real-time ultrasonic guidance for percutaneous puncture of the internal jugular vein. *Anesthesiology*. 1986;64(6):830-831.
10. Rothschild JM. Ultrasound guidance of central vein catheterization. In: *Making Health Care Safer: A Critical Analysis of Patient Safety Practices*. AHRQ Publication No 01-EO58. Rockville, MD: Agency for Healthcare Research and Quality; 2001:245-253.
11. National Institute for Health and Clinical Excellence. NICE Technology Appraisal No 49: Guidance on the use of ultrasound locating devices for placing central venous catheters. http://www.nice.org.uk/nicemedia/live/11474/32461/32461.pdf. Accessed March 2012.
12. O'Grady NP, Alexander M, Burns LA, et al. Healthcare Infection Control Practices Advisory Committee. Guidelines for the prevention of intravascular catheter related infections. *Am J Infect Control*. 2011;39(4 Suppl 1):S1-S34.
13. Milling TJ Jr, Rose J, Briggs WM et al. Randomized, controlled clinical trial of point-of-care limited ultrasonography assistance of central venous cannulation: The Third Sonography Outcomes Assessment Program (SOAP-3) Trial. *Crit Care Med*. 2005;33(8):1764-1769.
14. Bansal R, Agarwal SK, Tiwari SC, Dash SC. A prospective randomized study to compare ultrasound-guided with non-ultrasound guided double lumen internal jugular catheter insertion as a temporary hemodialysis access. *Ren Fail*. 2005;27(5):561-564.
15. Karakitsos D, Labropoulos N, De Groot E, et al. Real-time ultrasound-guided catheterization of the internal jugular vein: A prospective comparison with the landmark technique in critical care patients. *Crit Care*. 2006;10(6):R162.
16. Mallory DL, McGee WT, Shawker TH, et al. Ultrasound guidance improves the success rate of internal jugular vein cannulation: A prospective, randomized trial. *Chest*. 1990;98(1):157-160.
17. Hirvela E, Parsa C, Aalmi O, Kelly E, Goldstein L. Skills and risk assessment of central line placement using bedside simulation with 3-dimensional ultrasound guidance system. *Crit Care Med*. 2000;28:A78.
18. Sekiguchi H, Tokita JE, Minami T, Eisen LA, Mayo PH, Narasimhan M. A prerotational, simulation-based workshop improves the safety of central venous catheter insertion: results of a successful internal medicine house staff-training program. *Chest*. 2011;140(3):652-658.
19. Evans LV, Dodge KL, Shah TD, et al. Simulation training in central venous catheter insertion: improved performance in clinical practice. *Acad Med*. 2010;85(9):1462-1469.
20. Ma IW, Brindle ME, Ronksley PE, Lorenzetti DL, Sauve RS, Ghali WA. Use of simulation-based education to improve outcomes of central venous catheterization: a systematic review and meta-analysis. *Acad Med*. 2011;86(9):1137-1147.
21. Riopelle JM, Ruiz DP, Hunt JP, et al. Circumferential adjustment of ultrasound probe position to determine the optimal approach to the internal jugular vein: a noninvasive geometric study in adults. *Anesth Analg*. 2005;100(2):514.
22. Stone MB, Nagdev A, Murphy MC, Sisson CA. Ultrasound detection of guidewire position during central venous catheterization. *Am J Emerg Med*. 2010;28(1):82-84.
23. Ezaru CS, Mangione MP, Oravitz TM, Ibinson JW, Bjerke RJ. Eliminating arterial injury during central venous catheterization using manometry. *Anesth Analg*. 2009;109(1):130-134.
24. Rupp SM, Apfelbaum JL, Blitt C, et al. Practice guidelines for central venous access: a report by the American Society of Anesthesiologists Task Force on Central Venous Access. *Anesthesiology*. 2012;116(3):539-573.
25. Hind D, Calvert N, McWilliams R, et al. Ultrasonic locating devices for central venous cannulation: meta-analysis. *BMJ*. 2003;327(7411):361.
26. Kinsella S, Young N. Ultrasound-guided central line placement as compared with standard landmark technique: some unpleasant arithmetic for the economics of medical innovation. *Value Health*. 2009;12(1):98-100.
27. Domingo-Triadó V, Selfa S, Martínez F, et al. Ultrasound guidance for lateral midfemoral sciatic nerve block: a prospective comparative, randomized study. *Anesth Analg*. 2007;104(5):1270-1274.
28. Shiver S, Blaivas M, Lyon M. A prospective comparison of ultrasound-guided and blindly placed radial arterial catheters. *Acad Emerg Med*. 2006;13(12):1275-1279.
29. Hessel EA 2nd. Con: we should not enforce the use of ultrasound as a standard of care for obtaining central venous access. *J Cardiothorac Vasc Anesth*. 2009;23(5):725-728.
30. O'Leary R, Bodenham A. Future directions in ultrasound-guided central venous access. *Eur J Anaesthesiol*. 2011;28(5):327-328.
31. Ridley S. Farewell to history (editorial). *Anaesthesia*. 2010;65(9):877-879.

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