Ultrasound-Guided Central Venous Access

William R. Fry, MD; Gary C. Clagett, RVT, RDMS; P. Terrence O’Rourke, MD

Hypothesis: Real-time ultrasound guidance should increase the success rate and lower the complication rate of central venous access in patients with relative contraindications to having the procedure performed.

Design: Prospective case series.

Setting: A community-based tertiary care hospital.

Patients: Fifty-two patients were studied. Relative risks to central venous catheter insertion included (1) thrombosis or stenosis of central veins, (2) inherent or acquired anticoagulation abnormalities, (3) inability to assume a supine position, (4) hypovolemia, (5) obesity or altered anatomy, and (6) severe respiratory compromise.

Interventions: Real-time ultrasound evaluation of the proposed vein to be cannulated, followed by real-time percutaneous central vein access.

Main Outcome Measures: Successful cannulation of a central vein.

Results: All attempts at central vein cannulation were successful. No bleeding complications occurred. One pneumothorax occurred in an obese patient.

Conclusions: Ultrasound-guided central venous access is a helpful technique to gain venous access in difficult cases. Surgeons who perform central venous access procedures should become acquainted with the techniques involved. The techniques should be incorporated into currently developing ultrasound instruction courses for surgeons.

Arch Surg. 1999;134:738-741

Peripheral upper extremity veins are often not available because of previous use and sclerosis or an extended body habitus. More concentrated and caustic compounds have found increased application in the treatment of disease. Use of peripheral extremity veins does not provide sufficient blood flow rates to dilute these chemotherapeutic agents to non-caustic concentrations. Fears of extravasation with resultant local tissue toxic effects have forced a migration to use of central venous access. As a result, central venous access has become a mainstay of patient care. In the surgical community, central venous access is achieved routinely by a percutaneous route. Using the anatomic landmarks of the clavicle, deltopectoral groove, sternal notch, and sternocleidomastoid muscle, the subclavian and internal jugular veins can be accessed, with reported success rates from 67% to 96%.1-3

In the general population, central venous access is safe.5 Immediate complications include pneumothorax, bleeding, arterial puncture, catheter malposition, and death. Long-term complications include infection, catheter malfunction, catheter or vein thrombosis, and the potential for pulmonary embolus. Relative contraindications to central venous access include hypovolemia, bleeding disorders (inherent and acquired), the inability to assume a supine or Trendelenburg position, central vein occlusion, and the inability of the patient to physiologically tolerate complications, such as a pneumothorax. Our experience suggests lower success rates in patients with an excessive body habitus and those with a distorted anatomy (most often because of previous surgical intervention).

Ultrasound has been evaluated as an adjunct to central venous access under routine circumstances of central venous cannulation.2-5 The authors of these studies found that ultrasound guidance...
facilitates a higher success rate with a lower complication rate, but did not separate out their experience with patients at high risk or having relative contraindications to central venous access. The ability to access the central veins via sonographic guidance when anatomic landmarks alone fail has not been addressed. Therefore, we undertook an evaluation of ultrasound-guided central venous access in patients who had relative contraindications to central venous access. The ability to access the central veins via sonographic guidance when anatomic landmarks alone fail has not been addressed. Therefore, we undertook an evaluation of ultrasound-guided central venous access in patients who had relative contraindications to central venous access or a body habitus or disturbed anatomy that prevented conventional access via anatomic landmarks alone.

Central venous cannulation was successful in all patients. The subclavian vein was used in 43 patients, internal jugular vein in 7, and innominate vein in 2 (Table). In 3 patients, an unsuspected venous occlusion was diagnosed before the procedure was performed. Another site was chosen with ultrasound imaging and was cannulated successfully (Figure 1).

No bleeding complications occurred in patients with clotting disturbances. One pneumothorax occurred in a patient with an extended body habitus in which inadequate local anesthesia caused the patient to move with pain at a depth of 10 cm. In 1 hypovolemic patient, the “J” guide wire would not go into the vein, despite the ability to aspirate blood. Substitution of a straight guide wire with a flexible tip allowed completion of the procedure.

## METHODS

Before initiation of the procedure, the vein to be cannulated was imaged in B mode at the proposed site of percutaneous access. In both cases of innominate vein access, a supraclavicular ultrasound imaging approach was used for intended subclavicular percutaneous access. Confirmation of venous flow was obtained by color and spectral Doppler examination. Evaluation for stenoses of veins was performed by information gained from B mode, color, and spectral Doppler examinations.

For central venous access performed in the operating room, a 5-MHz linear probe (Acuson Corp, Mountain View, Calif) was sterilized using a sterilization system (Sterrad; Johnson & Johnson, New Brunswick, NJ). For bedside procedures, either a 5- or 7-MHz linear probe (Acuson) was used. It was prepared with betadine solution concurrent with preparing the patient’s skin. In all cases, a sterile packet of ultrasound gel (UltraPhonic Conductivity Gel; Pharmaceutical Innovations Inc, Newark, NJ) was used.

Once the vein was located and confirmed to be patent, freehand real-time access was performed using the access needle included in the central venous kit. When the depth of the central vein exceeded 2.5 cm, an 18-gauge spinal needle of appropriate length was used. Following the needle entering the vein, as evidenced by both ultrasound imaging and aspiration of blood through the needle, the Seldinger technique was used. Placement was confirmed both by aspiration of blood from the catheter and by upright chest radiograph.

### Results of Ultrasound-Guided Central Venous Access

<table>
<thead>
<tr>
<th>Veins accessed</th>
<th>Patients, No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subclavian</td>
<td>43</td>
</tr>
<tr>
<td>Jugular</td>
<td>7</td>
</tr>
<tr>
<td>Innominate</td>
<td>2</td>
</tr>
<tr>
<td>Initial ultrasound showing central vein</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Complications</th>
<th>Patients, No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleeding</td>
<td>0</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>1</td>
</tr>
<tr>
<td>Arterial puncture</td>
<td>0</td>
</tr>
<tr>
<td>Death</td>
<td>0</td>
</tr>
</tbody>
</table>

## COMMENT

The ability to percutaneously cannulate a central vein in this group of patients is notable. The complication rate is not zero and should serve as a caution. Although the ability to cannulate patent veins was our goal, it is not a foolproof technique.

The high impedance difference between air and soft tissue prevents imaging of the central veins with interspersed lung tissue between the skin and intended central vein. Because of the concave nature of a focused ultrasound beam, the lung may lie just outside the ultrasound
image acquisition area (Figure 2). Unlike other ultrasound-guided procedures such as breast biopsies, ultrasound-guided central venous access should be performed in the same plane where the ultrasound scan is performed. This is important with subclavian venous access. In the patient with emphysematous changes, it could also affect internal jugular venous access. Straying from the middle of the scan plane risks pleural injury and has the potential for pneumothorax.

Keeping the needle in the same plane as the ultrasound beam becomes more difficult with increasing depth because small degrees of change at the skin level are amplified at the tip of the needle. It therefore becomes easier to get out of the scan plane in the patient with an extended body habitus. Care must be taken to stay in the middle of the scan plane at increasing depths in order to avoid this potential hazard.

Qualitatively, awake patients who have ultrasound-guided central venous access seem less apprehensive. Their ability to watch what is going on via the ultrasound video screen, a decrease in the number of attempts, and better local anesthesia along the intended needle path have emerged as additional reasons to consider this technique.

Some argue that this technique should be used routinely with all percutaneous central venous access, but it is not the purpose of this study to prove or disprove such utilization. It is clear, based on our experience, that ultrasound-guided central venous access using anatomic landmarks alone have proven unsuccessful. The ability to access central veins in difficult cases in a safe and effective manner, as evidenced by our experience, suggests that surgeons performing central venous access procedures become familiar with the techniques involved. These techniques should be incorporated into ultrasound training courses for surgeons.

Presented at the 106th Scientific Session of the Western Surgical Association, Indianapolis, Ind, November 18, 1998.

Reprints: William R. Fry, MD, 25 E Jackson St, Suite 201, Colorado Springs, CO 80905 (e-mail: williamfry@centura.org).

REFERENCES

Felix D. Battistella, MD, Sacramento, Calif: Dr Fry and colleagues have shared with us their experience with using ultrasound to guide central venous catheter placement in 52 difficult and high-risk patients. Their results are outstanding. They achieved successful cannulation in all patients with only 1 complication, a pneumothorax in an obese patient.

First, how did you select your patients? Some, such as those with a coagulopathy or those with obesity, are easy to identify, but other groups you used this technique in were not as well defined. How many of the 52 patients had failed line placement using anatomic landmarks before a line was successfully placed using ultrasound? In which patients should we use ultrasound to assist with central venous cannulation? Should we use ultrasound in all those patients in whom we have failed to cannulate a vein using the standard external anatomic landmarks, or should we use ultrasound in difficult, high-risk patients? If so, which high-risk patients? Would you include the mechanically ventilated, edematous critically ill patients who can ill afford to have a pneumothorax in that latter category?

Second, can you tell us a little bit more about the hassle factor? Does it take longer to place the line using ultrasound? Is it cumbersome? If the answer is that it does not add significantly to the hassle factor, then do you recommend using ultrasound to place all central lines?

Throughout this meeting, we heard about the surgical applications of new technologies. It is apparent from many of the papers presented at this meeting and from recent reports that ultrasound has many diagnostic and therapeutic applications in surgery. The major surgical organizations have recognized this and are addressing the education of surgeons and residents in the use of ultrasound. However, given its broad applications, improvements in technology that simplify its use, and its noninvasive nature, do you think that we should promote the incorporation of instruction on ultrasound use into the basic skills curriculum of medical schools? Should ultrasound machines be placed in exam rooms next to otoscopes and ophthalmoscopes and on hospital wards next to the EKG machines? Is ultrasound the stethoscope of the new millennium?

Katherine Liu, MD, Chicago, Ill: This presentation addresses the difficult patients in whom we have trouble inserting a central line when they need one. I noticed that, in 13 of 52 patients, the indication for the central line was requiring central access for parenteral nutrition support or chemotherapy. Have you considered using a peripherally inserted central catheter, the so-called “PICC lines”? The use of PICC lines could avoid some of the complications associated with central lines such as pneumothorax. Although you did not have any bleeding complications in patients with coagulopathy when the line was inserted centrally, it is still a risk. By the use of PICC lines, we avoid these problems. I would like you to address these issues.

J. David Richardson, MD, Louisville, Ky: Do you make any attempt to correct the coagulopathy at all, or do you feel confident enough with the technique that, even with patients with 900 platelets or a PTT greater than 100, this is really safe? I always worry about this and would like your comments.

Dr Fry: Dr Battistella, how do we select our patients? Our main way of selecting patients, as this study showed, is in those people with coagulopathies, and those that we were unable to get a catheter in using anatomic landmarks. In the subset of patients in which central venous access had failed by landmarks alone by other surgeons, we used ultrasound guidance in our first attempt.

When to use ultrasound? I think you could certainly make a good argument that ultrasound could be used in all central venous access cases, although I do not have the data to prove that. Certainly, several studies have looked at this. I would say that my comfort level with ultrasound and the patient’s comfort level have increased over time.

In terms of mechanically ventilated patients, patients with high levels of PEEP or edematous patients, these were some of the patients who were at risk for pneumothorax, and I did not specifically delineate that in this manuscript, but there was 1 patient who had a PEEP of 20 in this group, as well as some severely edematous patients with anasarca.

Probably the biggest hassle factor is getting the machine to the bedside if you do not have 1 under control within your surgery department. I have a very good arrangement with our ultrasound department, and they are available within a few minutes of the time we call if it is an immediate case such as a bedside procedure, or we include scheduling ultrasound with the elective case in a patient with known central venous access difficulties. The biggest hassle factor in this procedure is that the needle is not well visualized. We really visualize only the motion of the needle, rather than the needle itself. Some other needles available are a little bit better visualized, but with a little bit of practice, the motion of the needle is sufficient.

Ultrasound should start to be taught in medical schools and in residencies. An ultrasound machine should be in every exam room and become part of our physical examination. I do not expect that to happen for another 5 to 10 years, but that is the way things should go.

Dr Liu, several of these patients have PICC lines and intercurrent infections, and thus the reason for central venous access. Also, we have had some trouble with drawing blood from these PICC lines and patients without other venous access. They get somewhat tired of having femoral sticks for blood draws.

Dr Richardson, working up the coagulopathies and treating them before line placement was of concern to me as well. I felt somewhat hesitant to put a femoral line in these patients without peripheral venous access to give them fresh-frozen plasma, platelets, etc, ahead of time because of the high risk of infection in those patients. I do not think I would have started out with a patient with 900 platelets to do this study, but that was later on in my experience.