Ultrasound-Guided Procedures in Emergency Medicine

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KEYWORDS

• Ultrasound • Emergency medicine
• Ultrasound-guided procedures • Central venous access
• Emergency ultrasound • Patient safety • Medical errors

Ultrasound may be used as an adjunct in many common procedures performed in emergency medicine, and has been demonstrated to improve effectiveness and reduce complications in diverse applications. Although the evidence is strongest for ultrasound guidance in central venous access, the use of ultrasound has been studied in many areas of procedural guidance.

Emergent procedures may also be performed by consultants in a location other than the emergency department (ED). Some of these procedures may be similar or identical to procedures performed by emergency physicians (EPs) in the ED. This article focuses on procedures that are commonly performed by emergency physicians that may benefit from ultrasound guidance.

TRAINING AND CREDENTIALING FOR ULTRASOUND-GUIDED PROCEDURES

Ultrasound is a user-dependent technology and experience using ultrasound in procedures will improve success. How much experience is necessary to use ultrasound effectively is controversial, incompletely studied, and will vary among individuals. Although guidelines have often focused on numbers of examinations or procedures, emphasis has shifted in the past several years to assessing competency rather than simply counting how many examinations or procedures have been performed.

The effective use of ultrasound includes a basic understanding of the physics and instrumentation of ultrasound as well as psychomotor and cognitive elements of image acquisition and interpretation.

The American Medical Association has endorsed specialty-specific guidelines for ultrasound training.[1] Within emergency medicine, the American College of Emergency Physicians (ACEP) has provided the most comprehensive specialty-specific guidelines for the use of emergency ultrasound, first published in 2001 and revised in 2008.[2,3] ACEP describes both residency-based and practice-based approaches to training in point-of-care ultrasound. Although the 2008 guidelines place more emphasis on competency rather than numbers, ACEP has generally recommended 150 total examinations with 25 to 50 in each specific area as a minimum for competency in diagnostic ultrasound. Procedural ultrasound is included in these guidelines; however, specific numbers of procedures required for competency have not been defined.

Privileging for the use of ultrasound as an adjunct for procedural guidance is generally a function of a local hospital or group credentialing committee. In most cases, EPs will be privileged to perform a procedure without ultrasound guidance. Additional proctoring and experience performing an ultrasound-guided procedure may be helpful, but many credentialing committees do not require a specific number of documented ultrasound-guided procedures as long as general principles of ultrasound are understood and sterile procedures are followed. In some cases, privileging guidelines may include a certain number of

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Ultrasound Clin 6 (2011) 277–289
doi:10.1016/j.cult.2011.03.005
1556-858X/11/$ – see front matter

proctored procedures before credentialing. Other avenues for training and assessing competency, including Web-based training and simulated procedures using phantoms have been advocated.[4,5]

GENERAL PRINCIPLES

The use of ultrasound to guide procedures generally involves directing a metallic object (usually a needle) into the correct area of interest. Although the specifics of individual procedures are discussed in more detail in the following sections, there are general principles and considerations that apply to most ultrasound-guided procedures. As with all procedures, appropriate consent should be obtained and a "time-out" performed with verification of correct side.

Machine and Transducer Selection

There are a wide variety of ultrasound scanners available, from high-performance cart-based equipment to handheld machines. Image quality in the portable and ultra-portable is improving and in most cases is adequate for procedural guidance, although improved visualization will aid in difficult procedures.

Most ultrasound-guided procedures are best performed with a high-frequency linear probe. Most procedures performed in the ED are relatively superficial and benefit from the increased resolution of high-frequency probes. In addition, the linear array allows localization of the structures of interest directly below the probe.

In situations where a structure of interest is particularly deep, a lower frequency curvilinear probe may be more appropriate, and in difficult to examine areas (peritonsillar, supraclavicular fossa) a high-frequency endocavitary probe may be most appropriate.

A specific preset for "procedural" or "vascular access" may optimize visualization of the needle. If these are not available, the best preset is usually "vascular" or "soft tissue." Tissue harmonic imaging may help to highlight the border of a fluid-filled structure.

Static and Dynamic Imaging

Ultrasound guidance for procedures can be static or dynamic. Static guidance involves assessing the area of interest and using ultrasound to note or mark where the needle should enter, at what angle, and so forth. Dynamic guidance involves watching the needle in real time, which can be done by the person performing the procedure (1-person), or by an additional person who does only the imaging while the other performs the procedure (2-person).

One-person dynamic guidance is a technique that involves simultaneous performance, ultrasound visualization, and visual monitoring of the procedure. This takes time and practice to master; however, for procedures involving small structures (especially nerve blocks and peripheral vascular access), 1-person dynamic imaging is preferred.[6]

For other procedures where there is a large amount of fluid, in particular when the transducer may actually interfere with where the needle is placed for the procedure, a static technique may be preferable. This is often the case with paracentesis, thoracentesis, and pericardiocentesis, particularly when large amounts of fluid are present.

Plane of Interrogation and Guidance

It is best to scan through the area of interest in 2 orthogonal planes to get a complete visualization of the anatomy and any pathology before any procedure. However, in a dynamic procedure the needle must be visualized in a single plane as the actual procedure is taking place. Relative to a needle, the 2 options are "in-plane" and "out-of-plane" (**Figs. 1** and **2**). Although the out-of-plane may be easier to use at first,[7] most sonologists prefer the in-plane approach for procedural guidance because the entire shaft of the needle, including the tip, is more easily visualized.[8] There are times when a short axis may have an advantage, particularly in locating the center of a small linear structure, such as a peripheral vein. In dynamic procedural guidance, the plane may be changed or adjusted during the procedure.

The other axis to be considered is long axis versus short axis relative to a tubular structure, such as a vessel, nerve, or tendon. A combination of long axis or short axis and in-plane or out-of-plane may be used. For example, an in-plane long axis approach may be preferable for central vascular access, whereas an in-plane short axis approach to a nerve may be best.

Sterile Technique

Sterile technique should be observed for most invasive procedures. This is best accomplished with a sterile probe cover kit designed for the specific probe. These kits will typically include a nonlatex cover that the probe can be lowered into as well as sterile gel for the outside of the cover. Although it is possible to use a sterile probe cover as a single operator, an assistant is very helpful. Gel should also be placed inside of the cover, but it does not need to be sterile. Although commercial probe covers are easiest to use, sterile gloves can also be accommodated to cover the probe if commercial probe covers are not available.