Emergency Ultrasonography and Error Reduction

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You are working an overnight shift in the critical care area of your emergency department (ED). Paramedics bring in an elderly patient from a nursing home with fever, shortness of breath, and a presumptive diagnosis of sepsis. She has a history of multiple medical problems and was recently admitted to your hospital for pneumonia. As you examine the patient, you observe that she is febrile, tachypneic, hypoxemic, tachycardic, and hypotensive. There are diffuse ronchi on examination and decreased breath sounds at the right base. A stat portable chest radiograph shows a moderate right pleural effusion and consolidation of the left lower lobe. The patient remains hypotensive despite boluses of crystalloid. You decide to place central venous access and an arterial catheter to assess her central venous pressure and mean arterial pressures. You consider thoracentesis to improve her respiratory status. Should you reach for the ultrasonography machine?

A decade has passed since Sankoff and Keyes1 proclaimed the importance of diagnostic emergency ultrasonographic training. In 2000, the Institute of Medicine’s sobering report To Err is Human prompted both legislative and regulatory initiatives to reduce medical errors.2 One year later, the federal Agency for Healthcare Research and Quality published a set of evidence-based patient safety guidelines3 that included the use of real-time ultrasonographic guidance for central venous catheter placement among the highest-rated patient safety practices. In the setting of accumulating evidence that ultrasonographic guidance improves patient safety and procedural success, we review the emergency medicine ultrasonographic data, with an emphasis on procedural guidance.

Any discussion of error reduction and emergency ultrasonography must begin with central venous catheterization, where the superiority of ultrasonographic guidance to the landmark technique has been demonstrated.4-7 The complications from attempted central venous catheter placement depend on the anatomic site and include hematoma formation, arterial puncture, pneumothorax, hemothorax, chylothorax, and air embolus. Traditionally, central venous catheter insertion was guided by surface anatomy estimates of vessel position. Ultrasonographically guided central venous access allows identification of vascular anatomy, visualization of the needle tip approaching and penetrating the target vein, and confirmation of successful puncture by visualization of the guidewire within the lumen of the vein.8 The potential error-reduction benefits of emergency ultrasonography for central venous catheter placement are most obvious in patients with limited pulmonary reserve, such as our hypotensive patient with bilateral pulmonary processes, who are less tolerant of iatrogenic pneumothorax. The reduction in complications compared with the landmark technique necessitates that emergency physicians perform central venous catheterization with ultrasonographic guidance whenever possible.

Emergency ultrasonography facilitates arterial catheter placement by allowing identification of the radial artery and surrounding anatomy. Shiver et al9 demonstrated a greater likelihood of first-pass success when using ultrasonography for arterial cannulation compared with the traditional palpation method, resulting in decreased patient discomfort and reduced complications.9 The authors state, “...[B]ecause arterial cannulation can cause significant pain and distress to our patients, it is the lower rate of repeating the procedure at another site that makes the greatest clinical difference.”

Thoracentesis, paracentesis, and pericardiocentesis are other common ED procedures in which ultrasonographically guided techniques have been shown to increase success or decrease the incidence of complications. Ultrasonographically guided thoracentesis allows visualization of the patient’s pleural effusion and surrounding anatomic structures, including lungs, liver, and diaphragm. Additionally, ultrasonography can help rule out other causes of the patient’s symptoms, such as atelectasis, consolidation, mass, or an elevated hemidiaphragm.10 Thoracentesis is one of the most frequent causes of iatrogenic pneumothorax, and ultrasonographically guided thoracentesis has been shown in multiple studies to reduce the rate of pneumothorax and the need for subsequent tube thoracostomy.11,12 Ultrasonographically guided paracentesis can reduce errors by allowing visualization of free intra-abdominal fluid and air-filled bowel loops. Nazeer et al13 showed that ultrasonographic guidance not only improves the rate of successful paracentesis but also helps determine the need for the procedure, thus reducing unnecessary intervention and patient discomfort. In addition, emergency ultrasonography is useful for diagnosing pericardial effusion14 and cardiac tamponade15 and also has been shown to improve success and decrease
complications of pericardiocentesis in both adult and pediatric patients.

Although it is less commonly used for this indication, emergency ultrasonography can facilitate lumbar puncture, another common and potentially painful ED procedure. This can be especially valuable in obese patients, in whom anatomic landmarks may be difficult to palpate. Recently published research has shown that ultrasonographic guidance reduced the number of failed lumbar puncture attempts in all patients and improved the overall success rate of the procedure in obese patients.

The procedural and diagnostic capacities of ultrasonography overlap in the management of abscess and other skin and soft tissue infections. Tayal et al. found that incorporation of emergency ultrasonography into the evaluation of skin and soft tissue infections resulted in a change in management in approximately half of cases. Use of emergency ultrasonography resulted not only in the identification of occult abscesses in cases of clinically suspected cellulitis but also in the prevention of unnecessary procedures when providers suspected abscess but emergency ultrasonography was consistent with simple cellulitis. Emergency ultrasonography can also be used to confirm peritonsillar abscess before drainage and to identify the location of the carotid artery to help avoid inadvertent puncture during needle aspiration.

The use of ultrasonographic guidance has also allowed the expansion of emergency physician scope of practice to include regional anesthesia. Although anesthesiologists use ultrasonographic guidance to improve regional anesthesia of the proximal extremity compared with traditional nerve stimulation techniques, Liebmann et al., Stone et al., and Blaivas and Lyon reported successful forearm and brachial plexus (supraclavicular and intercalane) blocks by emergency physicians with the use of ultrasonographic guidance. These blocks were not previously performed in the ED, where nerve stimulator technology and training is rarely available. Ultrasonographically guided regional anesthesia can reduce complications and patient discomfort by avoiding the need for (and risks associated with) procedural sedation, by decreasing the need to inject local anesthetic solution into a painful wound, and by reducing time to definitive treatment such as fracture reduction or abscess drainage.

Despite the data above, 66% of community EDs still do not have access to ultrasonography for emergency physician use. This is likely to change because both the Council of Residency Directors and the Accreditation Council for Graduate Medical Education (ACGME) have demonstrated a commitment to an emergency medicine residency curriculum in emergency ultrasound. In 2008, the Council of Residency Directors hosted a consensus conference on emergency ultrasonography, and the ACGME recently designated emergency ultrasonography as a procedural competency required for emergency medicine residents. In addition, the recently released 2008 American College of Emergency Physicians Guidelines specifically list procedural guidance as a core emergency ultrasonographic application, and identify vascular access, pericardiocentesis, paracentesis, thoracentesis, bladder aspiration, arthrocentesis, pacemaker placement and capture, and the management of soft tissue foreign body and abscess as possible indications for procedural ultrasonography. The use of ultrasonography for procedural guidance is rapidly becoming an integral part of emergency medicine.

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**REFERENCES**


