CHEST Topics in Practice Management

Ultrasound-Guided Thoracentesis*

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Pleural effusions are an extremely common problem affecting approximately 1.5 million people in the United States each year. Over the last several years, the use of portable ultrasound machines has greatly enhanced the evaluation and management of patients with pleural disease. This article will review the relevant literature supporting the use of ultrasound for the evaluation of patients with pleural disease and address some practical practice management issues regarding ultrasonography. ***(CHEST 2006; 129:1709–1714)***

Key words: pleural effusion; practice management; ultrasound

Abbreviations: ACEP = American College of Emergency Physicians; AMA = American Medical Association; CPT = current procedural terminology

Approximately 1.5 million persons are found to have pleural effusions each year in the United States.[1] Over the last several years, the use of portable ultrasound machines has greatly enhanced the evaluation and management of patients with pleural disease. Advantages of ultrasonography over standard chest radiography and CT include the absence of radiation, portability, real-time imaging, and the ability to perform dynamic evaluations. Ultrasonography has also been found to be more sensitive than chest radiography for the detection of pleural fluid,[2] and although slightly less sensitive than CT scanning,[3] ultrasonography is easier to perform and may better distinguish pleural thickening from pleural effusion. Although there is a learning curve associated with the use of ultrasound, it is relatively short.[4] Ultrasonography is also an excellent teaching tool, and we use it routinely to reinforce the physical examination of residents and medical students.[5] The American Medical Association supports the use of ultrasonography by nonradiologists. It is the responsibility of physicians in the other medical specialties, such as pulmonary and critical care medicine, anesthesia, emergency medicine, and surgery, to develop guidelines for training and incorporate this technology into daily practice. This article will review the relevant literature supporting the use of ultrasound for the evaluation of patients with pleural disease and address some practical practice management issues regarding ultrasonography, primarily as it pertains to nonradiologists.

Technical Aspects

Chest ultrasonography is primarily limited by reflection of ultrasound waves by bone and air. The acoustic window, therefore, is limited to the intercostal space. Fortunately, the presence of pleural fluid provides excellent contrast for pleural-based lesions on both the parietal and visceral pleura and can easily be seen between the hyperechoic air-filled lung and the diaphragm/liver/spleen or kidney. Examination of the pleural space with ultrasonography is best when using a convex array 3.5- to 5-MHz probe.[6] This frequency range provides both excellent resolution and penetration to allow visualization of deep structures in the chest. All ultrasound probes have a groove on one side that corresponds to a dot on the screen, typically found in the upper-left corner (Fig 1). By convention, the groove on the transducer is directed cephalad. It is therefore necessary to rotate the image on the screen 90° coun-

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The author has no conflict of interests.
Manuscript received January 13, 2006; revision accepted February 16, 2006.

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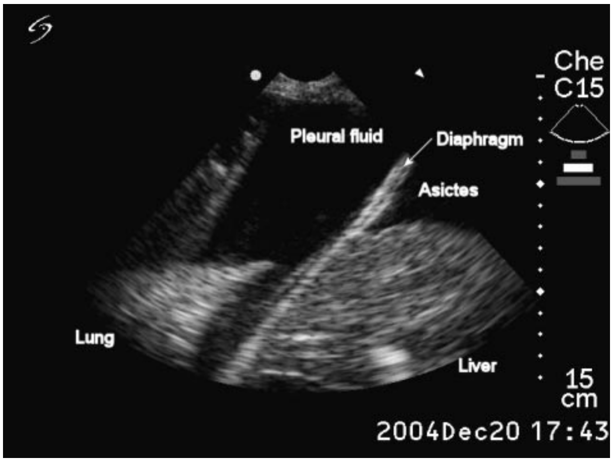

FIGURE 1. Overview of the right pleural space. The diaphragm can be seen on the right side of the image. The liver is used as a reference point to describe the echogenicity of the other structures. The hyperechoic air-filled lung can be seen floating in hypoechoic pleural fluid. (©2006 from *Ultrasound Guided Procedures and Investigations*, Armin Ernst, David Feller-Kopman, eds., Taylor and Francis, New York, NY 2006, Reproduced by permission of Routlege/Taylor & Francis Group, LLC).

terclockwise in your "mind's eye" in order to correlate the ultrasound image with the patient's anatomy. Practically, with the probe on the patient's back, the left side of the screen is cephalad, the right side of the screen is caudad, the top of the screen is posterior, and the bottom of the screen is anterior. The probe should then be moved in both the superior-inferior axis as well as transversely across the chest, within the intercostal space.

The skin and subcutaneous tissues are seen as multiple layers of soft-tissue echogenicity, and the parietal and visceral pleura are seen as two hyperechoic lines, typically < 2 mm thick.[7] In the absence of pleural fluid, identification of the hyperechoic visceral and parietal pleurae can be difficult.[6,8] Air-filled lung appears as patterns of bright echoes caused by reverberation artifact. As air enters the lung during inspiration, these echoes become brighter, *ie*, more hyperechoic. Movement of the underlying lung with respiration produces a "sliding" or "gliding" sign, and this dynamic movement identifies the visceral pleura and lung parenchyma. Diaphragmatic movement can also be visualized in real-time and is a key reference point when starting to perform ultrasound examination of the pleural space. The liver is used as an echo reference for the definition of hypoechoic, isoechoic, and hyperechoic reflections (Fig 1).

Ultrasonographic Features of Effusions

Several studies have found that ultrasonography can be helpful in distinguishing transudative from exudative pleural fluid. Although an early study[9] found that complex, or septated, fluid correctly identified exudates 74% of the time, more recent data[10] suggest that complex effusions (either septated or nonseptated) or homogenously echoic effusions are always exudates. The converse, however, may not be true. Although transudates are almost always anechoic, anechoic fluid can be either transudative or exudative. Pleural thickening in association with a parenchymal abnormality also correlates with exudative fluid, and homogenously echogenic effusions are typically seen with hemorrhage or empyema.[10] Clearly, in order to correctly correlate the ultrasonographic characteristics of effusions, more experience is necessary than what is required solely for identification of pleural fluid. The presence of septations on ultrasound imaging has been found to predict the need for pleural interventions such as intrapleural fibrinolysis or surgical debridement, and is also associated with an increased duration of chest tube drainage and hospital stay.[11] These data, however, were reported prior to the recent trial by Moskell and colleagues,[12] suggesting a lack of efficacy of fibrinolytics for treating empyema. The exact role of ultrasound for predicting further invasive therapy remains to be defined.

The volume of fluid in the pleural space can be estimated sonographically, and when examining patients in the supine position, the volume of fluid seen on ultrasound correlates better with actual fluid volume than the amount of fluid estimated from a lateral decubitus chest radiograph.[13] Two important points in using this method of evaluating pleural fluid volume are that the transducer needs to be perpendicular to the chest, as an oblique angle will overestimate or underestimate volume. Additionally, patients with larger chests will distribute a given amount of fluid over a larger area, and therefore reduce the estimated volume seen with ultrasound.

As pleural thickening can be anechoic, the sole presence of an echo-free space does not guarantee the presence of pleural fluid. Dynamic changes, including the change of shape with respiratory movement, or the presence of movable echo densities, are therefore considered the *sine quo non* of pleural fluid.[14] Some authors[15,16] advocate the use of the fluid "color signal," the change in color seen during respiratory or cardiac motion, to identify small or loculated effusions.

Ultrasound has also been evaluated in patients with "white out" of a hemithorax. Using CT as the "gold standard," ultrasound has a 95% sensitivity for detecting pleural lesions in this group of patients.[3] As one would expect, the ability of ultrasound to detect parenchymal or mediastinal pathology is more limited when compared to CT. The benefits of ultrasound, however, include its portability, cost, lack of radiation exposure, and ability to perform dynamic and real-time procedural guidance at the bedside. Ultrasound has also been shown to aid in obtaining adequate fluid from small effusions (defined as obliteration of less than half of the hemidiaphragm), regardless of whether the fluid was loculated or not.[17]

Guidance for Thoracentesis

Thoracentesis is typically thought to be a relatively safe procedure with few complications. The incidence of pneumothorax, however, has been reported to be as high as 20 to 39%.[18] Procedural factors that have been shown to reduce the rate of pneumothorax include the performance by experienced personnel,[19] as well as the use of ultrasound.[18,20,21]

Although there are no blinded randomized trials comparing ultrasound-guided vs physical examination-guided thoracentesis, several studies have associated ultrasound use with lower complications. Grogan and colleagues[18] found a significant reduction in the pneumothorax rate when ultrasound was utilized for identification of needle placement (0% vs approximately 29%). A similar reduction in the rate of pneumothorax was also seen by Raptopoulos et al[21] (18% vs 3%). This held true whether the amount of pleural fluid was deemed small or large, whether the thoracenteses were diagnostic or therapeutic, and whether the tap was "dry" or "near dry." Perhaps even more clinically relevant, the occurrence of pneumothorax requiring tube thoracostomy is also significantly reduced with ultrasound guidance.[21,22]

Most studies of ultrasound guided thoracentesis do not use real-time guidance for needle insertion, but insert the needle immediately after identification of an appropriate site. Interestingly, this "X marks the spot" technique, when performed with delay in needle insertion, *ie*, having a radiologist use ultrasound to mark the needle insertion site with the thoracentesis being performed when the patient returned to the floor, is not associated with a reduction in the pneumothorax rate.[21]

Another benefit of ultrasound has been an increased success in thoracentesis even after a failed clinically directed thoracentesis. Several studies[9,17,23] suggest that fluid can be successfully obtained in up to 88% of patients after unsuccessful clinically guided thoracentesis. Perhaps even more importantly, in 58% of clinically attempted "dry taps," the needle insertion site was found to be below the diaphragm.[23] Diacon et al[24] found that ultrasound increased the rate of accurate site selection by 26%, and decreased the number of near misses, *ie*, the number of potentially dangerous needle insertion sites by 10% when compared to fluid localization by physical examination and chest radiography.

Critical care physicians can easily acquire the sonography skills required to guide thoracentesis in the ICU, and can do so without formal radiology training.[4] Mayo and colleagues[4] had a 1.3% pneumothorax rate in their study of 232 ultrasound-guided thoracenteses in patients requiring mechanical ventilation. For patients in the ICU, it is uncommon for us to sit the patient upright, a task that often requires at least two assistants. We generally scan the lateral chest wall with the patient supine and the ipsilateral arm brought over the chest to the opposite side. This position is easiest for the patient and the nurse, and moderate effusions can easily be seen. With smaller effusions, the head of the bed may need to be raised, or we slide the patient closer to the edge of the bed so the ultrasound probe can be placed more posteriorly.

Pneumothorax

Although easily seen by conventional chest radiography or chest CT, the portability of ultrasound, especially when used at the point of care, makes this technology especially useful for ruling out a postprocedural pneumothorax. Loss of lung sliding as well as the loss of "comet tail" artifacts strongly associate with the presence of pleural air.[25] Comet tail artifacts are caused by echo reverberations of the air-filled lung, and appear as narrow hyperechoic ray-like opacities extending from the pleural line to the edge of the ultrasound screen. Lung sliding can also be limited by pleural-parenchymal adhesions or diaphragmatic paralysis, and therefore the main utility of ultrasound for assessment of pneumothorax relates to its ability to rule out a pneumothorax. That is, the presence of comet tail artifacts and lung sliding rules out a pneumothorax with a negative predictive value of 100%.[26,27] Although ultrasound can rule out a pneumothorax, it cannot quantitate its size when present, and standard radiographs are required. Lichtenstein et al[28] has recently reviewed the utility of ultrasound for the identification of pneumothorax, and describes the visualization of the "lung point" with the time-motion mode as a very specific sign (100%) to identify pneumothorax. Also important to the pulmonologist is a recent small study[29] using ultrasound to rule out pneumothorax after transbronchial biopsy.

Practice Management Implications

The policy of the American Medical Association (AMA) on privileging for ultrasound imaging states the following:

ultrasound imaging is within the scope of practice of appropriately trained physicians. . . broad and diverse use and application of ultrasound imaging technologies exist in medical practice. . . privileging of the physician to perform ultrasound imaging procedures in a hospital setting should be a function of hospital medical staffs and should be specifically delineated on the Department's Delineation of Privileges form. . . each hospital medical staff should review and approve criteria for granting ultrasound privileges based on background and training for the use of ultrasound technology and strongly recommends that these criteria are in accordance with recommended training and education standards developed by each physician's respective specialty.[30]

This policy affirms that ultrasound is not limited to the domain of radiologists, and the AMA also supports reimbursement for "appropriately trained physicians.

The American College of Emergency Physicians (ACEP), for example, has taken action and developed a policy statement[31] addressing the scope of practice, training, and proficiency recommendations, quality improvement, and documentation issues regarding the use of ultrasonography in the emergency setting. Likewise, the American College of Surgeons has also approved a statement[32] describing the use of ultrasound by surgeons. Both of these documents strongly support the use of ultrasound by members of their societies and address ways to obtain and maintain competency, as well as ensuring quality control. Unfortunately, the American College of Chest Physicians, the American Thoracic Society, and the Society of Critical Care Medicine have yet to develop or publish their recommendations. As the use of ultrasonography is expanding among pulmonologists and intensivists,[33,34] we need to develop a policy that addresses similar issues, as well as how to train our fellows in a procedure that they will certainly need to be as facile with as the flexible bronchoscope.

To gain the skills required to incorporate ultrasonography in clinical practice, the nonradiologist needs to become proficient in both cognitive and psychomotor skill sets. Training in image acquisition and interpretation needs to include didactic lectures, demonstrations, and most importantly, proctoring by a skill sonographer. The ACEP suggests a 2-day (16-h) course to cover all aspects of ultrasonography geared toward the emergency department physician, but also acknowledges that less training is necessary for those wishing to learn only one application.[31] For a single application, the ACEP recommends 3 to 4 h of didactics and 2 to 4 h of laboratory training. Although it is difficult to determine competence solely based on the number of examinations performed, the ACEP suggests at least 25 cases be documented and reviewed for each primary application. The cases should include both normal and abnormal findings, and continued training in order to ensure skill maintenance is a must.[31] There are several continuing medical education courses given throughout the country, and attendance at the American College of Chest Physicians and Society for Critical Care Medicine sessions on ultrasound use have been increasing almost logarithmically. Additionally, self-study courses are also available specifically geared toward pleural ultrasound (www.sonographytraining.com). Continued quality assurance for both the sonographer and the equipment is also essential. As the AMA suggests, it will the responsibility of our societies to develop specific guidelines addressing training and education standards.

The chest physician should review the current procedural terminology (CPT) codes with their local billing expert as well as their local third-party payers, as reimbursements vary between regions, and even within a state. The two most commonly used codes for thoracentesis are 32000 and 32002. Code 32000 describes "thoracentesis, puncture of pleural cavity for aspiration, initial or subsequent" and has an associated Medicare payment of approximately $190.69 (nonfacility) and $82.00 (facility) in Massachusetts (www.catalog.ama-assn.org/Catalog/cpt/cpt_search.jsp?_requestid=244532). Code 32002, however, is described as "thoracentesis with insertion of tube with or without water seal (*eg*, for pneumothorax) (separate procedure)" and has an associated Medicare payment of approximately $223.87 (nonfacility) and $132.94 (facility) in Massachusetts. This is a distinct code from 32020, "tube thoracostomy with or without water seal (*eg*, for abscess, hemothorax, empyema) (separate procedure)", which has a Medicare reimbursement of $222.00 (nonfacility and facility) in Massachusetts. These codes distinguish "diagnostic" thoracenteses, when just a small needle is used, from "therapeutic" thoracenteses, in which a kit containing a catheter over a needle is used, from frank tube thoracostomy. The physician therefore should appropriately document when a therapeutic thoracentesis is performed, and should bill 32002 if a kit containing a catheter is used for the procedure.

The most commonly used CPT codes for ultrasound guidance relevant to the chest physician/intensivist include 76942 ("ultrasonic guidance for needle placement, [*eg*, biopsy, aspiration, injection, localization device], imaging supervision and interpretation"); 76937 ("ultrasound guidance for vascular access requiring ultrasound evaluation of potential access sites, documentation of selected vessel patency, concurrent real-time ultrasound visualization of vascular needle entry, with permanent recording and reporting [list separately in addition to code for primary procedure"]); and 76604 ("ultrasound, chest, B-scan [includes mediastinum] and/or real time with image documentation") [www.catalog.ama-assn.org/Catalog/cpt/cpt_search.jsp?_requestid=244532]. It should be noted, however, that the above codes are the technical component and can only be billed by the service that owns the ultrasound equipment. The professional component is billed by using the "-26" modifier. Since the technical component is significantly higher than the professional component, it may make financial sense for the physician's office or division to purchase the ultrasound unit themselves, as opposed to using one owned by the hospital. In metropolitan Boston, the reimbursement for code 76942 is $175.00 ($138.56 technical, $36.44 professional component), and the reimbursement for code 76937 is $38.13 ($21.25 technical, $16.88 professional component) [www.cms.hhs.gov/apps/pfslookup/].

As with all billing practices, it is the physician's responsibility to ensure proper billing and documentation, and the reader is urged to review local requirements with their insurance companies and billing experts. It is also crucial to discuss reimbursement with third-party payers, as they may wish to have a letter from the chief of radiology at your institution stating you have achieved competency. This is yet another reason why our societies need to take an active role in advocating for our own ability to determine competency.

In addition to using the proper CPT codes, adequate documentation is a must. For ultrasound, either a hard copy or electronic copy of the pertinent images need to be saved in the medical record. This needs to be done in accordance with the Health Insurance Portability and Accountability Act guidelines, and all patient identifiers need to be safeguarded if the images are to be stored electronically.

Limitations to Ultrasonography

There are some realities one needs to face, however, prior to embracing ultrasound for all thoracenteses. First, there are no blinded randomized trials proving improved outcome. As these trials would be extremely difficult, if not impossible, to design, we will likely need to rely on the current grade B evidence. Clearly, experienced pulmonologists can perform thoracentesis safely without ultrasound guidance.[35] At this time, each of the relevant risks and benefits of performing thoracentesis with or without ultrasound guidance need to be assessed on a case-by-case basis. The obvious benefits of the pulmonologist performing the thoracentesis, as opposed to having the procedure performed by a radiologist, in an off-site location include patient continuity, the guarantee that the appropriate procedure is performed (diagnostic vs therapeutic tap), and the fact that the pulmonologist has been trained in the interpretation of pleural fluid results and can provide pleural-specific follow-up. There are, however, cases in which the pulmonologist who does not perform ultrasound would clearly want his/her radiology colleagues to perform the procedure. Additionally, some small/loculated effusions would be better drained by CT as opposed to ultrasound guidance. Secondly, there are numerous ultrasound machines available, each with their own advantages and disadvantages, and although "bells and whistles" may be nice to have, they are not required, and simple/older machines can be adequate for most needs. The initial financial investment can be quite significant (approximately $25,000 to $40,000), although new and used equipment can even be found on Internet sites such as "e-Bay" for significantly less money. Additionally, maintenance costs and costs of additional supplies such as sterile sheaths and a printer need to be budgeted. Thirdly, and perhaps most importantly, quality assurance needs to be high on all of our priorities. Although easily learned, both didactic and real-time education is required. As with other procedures, competence is likely partly numbers based; in order to maintain proficiency, a certain number of examinations should be performed on a regular basis.

Summary

Ultrasonography is an easily learned procedure that not only enhances the physical examination but has the distinct advantages of being a portable tool that can provide real-time evaluation of the pleural space. Its use has been associated with an improved yield and reduced complication rate for thoracentesis, and is quickly becoming the standard of care for procedural guidance. As chest physicians/intensivists, we need to embrace ultrasounds broad clinical applications in patients with pleural disease, as well as guidance for vascular access, and even cardiac echo and trauma evaluation. It is crucial that chest physicians take the lead in advocating for ultrasound to become part of our daily practice, create educational opportunities for members of our societies, and incorporate ultrasound training in our fellowship programs.

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