

Ultrasonography in the Diagnosis and Management of Pleural Diseases

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Introduction

The role of ultrasonography in the diagnosis and management of different diseases is every changing because of changes not only ultrasound technology, but also due to changes in technology in the “competing” modalities, such as computed tomography and magnetic resonance imaging. Due to the many advantages of ultrasonography, however, including its safety (1), portability, and real-time image display, this modality continues to play an important and perhaps growing role in modern medicine.

The most common use of ultrasonography in the thorax has been, and likely will continue to be, the imaging of the heart. Traditionally, imaging of the lungs has been limited, at best, because of very poor transmission of the sound waves through air. However, it has long been recognized that ultrasonography is quite suitable for imaging the pleural space. Indeed the real-time response of ultrasonography has made it the ideal modality

for not only imaging some pleural diseases, but also for guiding interventions involving the pleural space.

Pleural Effusion

While the soft tissues of the thoracic wall demonstrate a complex pattern when reflecting sound waves, due to the numerous soft tissue interfaces within them, pure fluid such as that seen in a simple transudative pleural effusion provides an ultrasound image that is free of echoes and very easy to identify. For this reason, ultrasonography is perhaps the ideal modality for imaging pleural effusions. Figure 1 illustrates the normal pleura. It can be seen as bright white line. The lung, deeper to the pleura, is not seen because the interface between the visceral pleura and the air results in the reflection of nearly all of the sound waves, leaving nothing but shadow (white) visible in the lung. During real time viewing, the gliding of the pleura can be seen (an important sign for distinguishing normal lung from pneumothorax). Figure 2, however, demonstrates a large

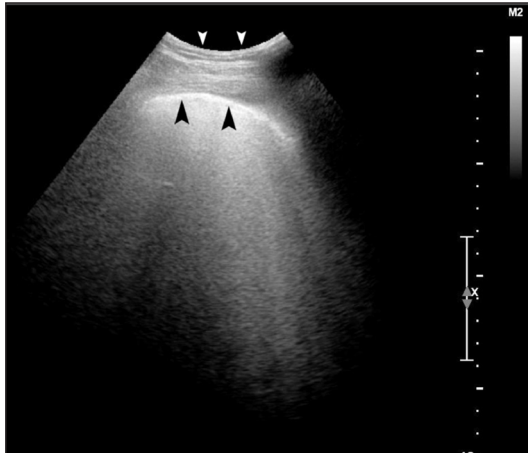


Figure 1: Normal pleural. The transducer contacts the skin at the point marked by the white arrowheads, and is oriented to create a sagittal image, where the left side of the image represents the superior direction. The normal pleura is seen as a bright white line (black arrowheads). Deep to the pleura there is only shadowing (bright lines) from the aerated lung.

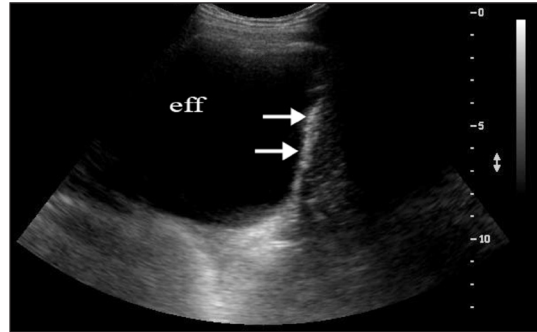


Figure 2: Transudative pleural effusion. The effusion (eff) is anechoic (black and lacking internal echoes). The image is oriented the same as in Figure 1. In this image, the diaphragm (arrows) is well outlined by the effusion. While transudative pleural effusions classically appear as anechoic on ultrasonography, an exudative effusion can have this appearance as well.

transudative pleural effusion. The effusion is easily seen as a large anechoic (black) area.

It is well-known that pleural effusions can be identified on plain radiography, ultrasonography, computed tomography (CT) and magnetic resonance imaging (MRI). While CT and MRI may play a role in the evaluation of some patients (2-4), routine pleural imaging has largely been with either plain radiography or ultrasonography.

Plain radiography is well-known for its ability to detect the presence of pleural effusions. And while it has long been established that an upright chest film can detect as little as 25 cc of pleural fluid⁵, or even less with a decubitus view (6), it has also been long-established that ultrasonography is more sensitive and specific for the detection of pleural effusions, especially smaller effusions (7,8). Indeed, the paper by Collins, et al (5) found that up to 525 mL of pleural fluid could be present without visible blunting of the costophrenic angle on an upright PA view of the chest. Fi-



Figure 3: Small pleural effusion. The effusion (eff) is smaller than that of Figure 2, but otherwise has similar imaging characteristics on ultrasonography. The diaphragm (arrow) is partially outlined by the effusion. This effusion was not visible on portable chest radiography.

gure 3 illustrates a small pleural effusion that was detected by ultrasonography but not visible on a supine chest radiograph.

Not only does ultrasound excel in the detection of pleural fluid, but it is also superior to plain radiography in quantifying the amount of fluid present in the pleural space (9) While not always of criti-

cal importance, it is often useful to determine the size of a pleural effusion because of its significance in determining etiology (10), prognosis (11) or in guiding treatment (12-15).

Finally, ultrasonography can play a role in the characterization of pleural effusions as transudates or exudates. Typically, pleural effusions on ultrasonography can be classified into three groups;

1. Anechoic,
2. Complex, non-septated,
3. Septated. An anechoic pleural effusion appears as homogeneously black. There is general agreement that both transudates and exudates may appear as anechoic fluid collections on ultrasonography (16,17). A complex, non-septated pleural effusion shows some internal echoes. This pattern can be seen in both transudates and exudates (18). The final pattern, septated, however, is exclusively seen in exudates (16,17). Thus, the anechoic pleural effusion shown in Figure 2 could be either a transudate or an exudate (though it was shown by clinical history and chemical analysis to be a transudate), the effusion shown in Figure 4 must be an exudate because of the presence of prominent septations throughout it.

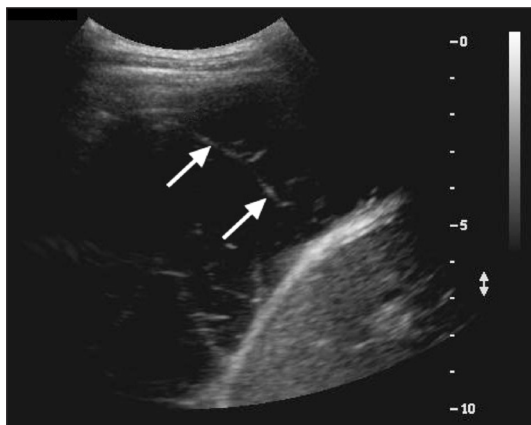


Figure 4: Septated pleural effusions. There are thick septations (arrows) in this pleural effusion. The presence of septations is highly specific for exudative pleural effusion.

Thoracentesis

The work up or treatment of a pleural effusion often requires thoracentesis (19). Because of its portability and real-time imaging, ultrasonography can be used for guidance during thoracentesis. The use of ultrasonographic guidance has been shown to be both safe (20-24) and effective (25,26). While there is continued debate about whether all thoracenteses should be performed with ultrasonography, it is certainly preferred in complicated cases (small or loculated pleural effusions, large body habitus or patients under mechanical ventilation) (22,23) and in cases where an attempt without ultrasonographic guidance has been made and failed (27,28).

In some cases, such as empyema, it may be necessary to place an indwelling percutaneous drainage catheter within the pleural space (29,30). While management by blind placement of a large-bore chest tube is often appropriate (30), ultrasound guidance can be used for the accurate and safe placement of small-bore drainage catheters (31-33). Figure 5 illustrates an ultrasonographic ima-



Figure 5: Ultrasonographically-guided chest tube placement. The chest tube (arrows) is well seen within the pleural space. The visceral pleura (arrowhead) is visible just deep to the chest tube.

ge that confirms appropriate positioning of a chest tube into the pleural space.

Pneumothorax

While the role of ultrasound in the diagnosis of pneumothorax is not nearly as well-established as for pleural effusion, it is known that ultrasound can be used for accurate and rapid diagnosis of pneumothorax (34). On a static image, the shadowing caused by air in the pleural space cannot be distinguished from air in the lung parenchyma. During real-time imaging, however, a pneumothorax can be diagnosed due to the absence of the normally observed gliding between the two layers of the pleura (35,36). While it is not suggested that ultrasonography replace plain radiography for the routine diagnosis of pneumothorax, there will be many times when ultrasonography is already being performed for another indication, and the additional scanning for the presence of a pneumothorax can be easily performed. Perhaps the most-studied scenario is that of the trauma patient, where ultrasound may be utilized as a part of the focused assessment with sonography for trauma (FAST) exam or a related protocol (37-39). As ultrasonography is used more commonly for interventional procedures in the chest, such as central line placement and thoracentesis, it is possible that more attention will be placed on using the ultrasonography machine already in the room to make the immediate diagnosis of pneumothorax when that complication occurs.

Pleural Thickening

Ultrasonography can be used to readily distinguish pleural fluid from pleural thickening (40,41). The use of color Doppler ultrasound, which is sensitive to motion and renders pixels in color where motion is detected but grayscale where no motion is detected, will demonstrate the motion of pleural fluid during the cardiac and respiratory cycles, but will reveal no motion (no color) in pleural thickening (42).

Pleural Masses

Both benign and malignant masses may arise in the pleura. In addition, the pleura may be involved secondarily by either direct extension or hematogenous spread of malignancy. In general, ultrasonography does not play a role in diagnosing the different types of benign (lipoma, solitary fibrous tumor of the pleura, and others) or malignant (malignant mesothelioma and metastases) tumors, and ultrasonography generally cannot even reliably distinguish benign tumors from malignant ones (43). The role of ultrasonography in the evaluation of pleural masses is largely that of localization and guidance for percutaneous biopsy (44) Figure 6 shows a mass (Ewing's sarcoma) that had directly invaded into the pleural space.

Pleural Biopsy

Biopsy of the pleura may be necessary in cases where thoracentesis fails to provide a diagnosis in a suspected exudative effusion, or in cases of pleural thickening or pleural masses where histology is required to make a diagnosis (45). While both computed tomography and ultrasonog-

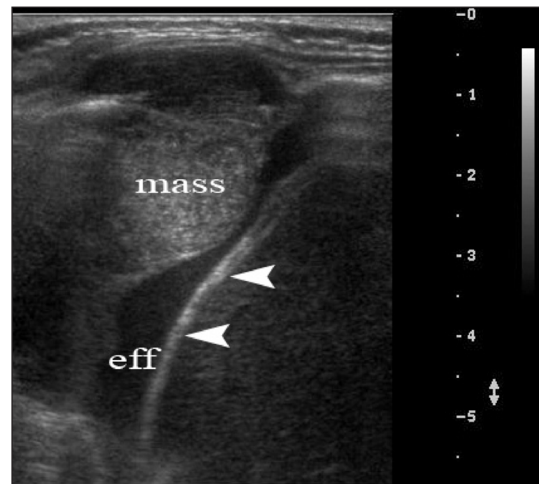


Figure 6: Pleural mass. This Ewing's sarcoma (mass) directly invaded the pleural space. There is an associated malignant pleural effusion (eff) visible adjacent to the mass. The effusion also outlines the diaphragm (arrowheads).

raphy can be used safely as image guidance for pleural biopsies, (46-48) ultrasonography can be particularly useful in guiding pleural biopsies when there is a focal lesion that is well-seen with that modality and in cases where real-time visualization of the biopsy needle is felt to be important.

Conclusion

Ultrasonography plays an important and growing role in the diagnosis and management of pleural disease. Despite the increasing use of computed tomography, ultrasonography's ability to provide real-time images, its portability, low cost and unique basis of image contrast make it useful for a large number of both diagnostic and therapeutic scenarios.

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