Point of Care Ultrasound for the General Internist: Pleural Effusions

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DOI: 10.22374/cjgim.v13i2.231

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Submitted: August 8, 2017. November 10, 2017. Published June 25, 2018.

ABSTRACT

Pleural effusions are a common finding in many clinical settings and have important diagnostic and therapeutic implications. They may be identified by physical exam, chest radiography, chest computerized tomography (CT) scans or point of care ultrasonography (POCUS). The use of POCUS for the diagnosis and management of pleural effusions offers several advantages relevant to the practice of the general internist. POCUS in-fact has superior sensitivity and specificity for locating pleural effusions, when compared to chest radiography and physical exam. Abnormal sonographic features of the pleural fluid and the adjacent pleura may also suggest the presence of an exudative or malignant effusion. POCUS additionally can be used to quickly estimate the size of a pleural effusion. Lastly, the use of ultrasound guidance when performing a thoracentesis reduces the risk of a pneumothorax and/or hemorrhage.

RESUME

Les épanchements pleuraux sont courants dans de nombreux contextes cliniques et ont des implications diagnostiques et thérapeutiques importantes. Ils peuvent être identifiés par un examen physique, une radiographie thoracique, une tomodensitométrie thoracique (TDM) ou une échographie au point de service (POCUS). L'utilisation de POCUS pour le diagnostic et la gestion des épanchements pleuraux offre plusieurs avantages pertinents pour la pratique de l'interniste général. En fait, POCUS a une sensibilité et une spécificité supérieures pour localiser les épanchements pleuraux, en comparaison avec la radiographie thoracique et l'examen physique. Les caractéristiques échographiques anormales du liquide pleural et de la plèvre adjacente peuvent également suggérer la présence d'un épanchement exsudatif ou malin. POCUS peut en outre être utilisé pour estimer rapidement la taille d'un épanchement pleural. Enfin, l'utilisation du guidage échographique lors d'une thoracentèse réduit le risque de pneumothorax et/ou d'hémorragie.

Pleural effusions are a common finding in many clinical settings and have important implications for diagnosis and management. The incidence of pleural effusion on medical wards ranges from 16–62%.¹ A pleural effusion may be identified by physical exam, chest radiography, chest computerized tomography (CT)

scans, POCUS or a combination thereof. The most common test currently used is the standard two-view chest radiograph. It is widely available and convenient to obtain; however standard views can be time consuming and logistically challenging to obtain in acutely ill medical inpatients. In these circumstances,

physicians rely on a single supine anterior-posterior chest radiograph to help guide management, which can lead to a missed or misdiagnosed pleural effusion.²

Thoracic ultrasonography has been available since the 1960s but has lacked widespread adoption due to the comparative ease and low cost of chest radiography. With recent improvements in ultrasound portability and cost, the detection of pleural effusion with bedside or point of care ultrasonography (POCUS) has become more common in clinical practice in multiple areas of medicine.

POCUS offers fast, accurate detection of pleural effusions and reduces the complications associated with thoracentesis.^{3,4} In this article, we summarize the evidence supporting the use of POCUS for the diagnosis and management of pleural effusions as relevant to the practice of the general internist.

Diagnostic Performance of Ultrasound

For the diagnosis of pleural effusions, POCUS has superior sensitivity and specificity when compared to chest radiography and physical exam. To better understand this, it is worthwhile to briefly review how a pleural effusion is diagnosed using ultrasound.

Ultrasound images are typically acquired with a patient in a sitting or supine position. Diagnosis requires the identification of fluid within the pleural space, which typically (but not always) appearing as an anechoic (black) area between diaphragm, lung and chest wall (Figure 1). Crucial to confirming the presence of a pleural effusion is additionally identifying the thoracic

spine. In contrast to chest radiography, in which structures of the thorax are superimposed upon on another; ultrasound images are acquired in a transverse or sagittal plane, making the identification of pleural fluid comparatively easy for even small volumes of pleural fluid. If chest CT is used as the gold standard, POCUS has superior test characteristics compared to chest radiographs, primarily due to a markedly greater sensitivity (sensitivity 94% vs. 51%, specificity 98% vs. 91%, respectively).⁵ Despite technical limitations, pocket-sized ultrasound devices have also demonstrated similar superiority in comparison to supine chest radiography (sensitivity 91% vs. 74%, specificity 100% vs. 32%, respectively).⁶ In one study, with minimal 3 hours of focused training, novice residents were able to achieve excellent inter-rater reliability compared with experts.⁷

In contrast, physical exam has only moderate sensitivity and specificity when compared to chest radiography for this purpose (sensitivity 73%, specificity 74%).⁸ Compared to CT scans as the reference standard, diagnostic accuracy of POCUS also outperformed chest radiograph and auscultation for the detection of pleural effusion in critically ill patients (diagnostic accuracy of 93%, 47%, and 61%, respectively).⁹

Using an ultrasound probe in diagnosing pleural effusions, a General Internist undoubtedly has a number of significant advantages. As summarized in Table 1, ultrasound has superior sensitivity and specificity in detecting pleural effusions when compared to physical exam or chest radiography. Furthermore, a focused ultrasound examination of the lungs, in experienced hands can be performed and interpreted within minutes at the

Figure 1. A sagittal ultrasound image of a pleural effusion (E), with lung tip (L), diaphragm (D), spine (S), and spleen (Sp) identified. The pleural effusion appears anechoic (black). Depth is displayed on the right of the image in centimeters.

bedside.¹⁰ Lastly, differential diagnostic considerations on chest radiography such as consolidation, atelectasis and pleural disease are also often easily visualized by ultrasound.²

Exudative and Malignant Effusions

An additional advantage of POCUS is that it is also able to detect features of exudative and malignant pleural effusions. These signs of an exudative and malignant effusion are often reflected in sonographic abnormalities of the pleural fluid and pleura.

The sonographic appearance of pleural fluid can be divided into four patterns: anechoic (see Figure 1), complex non-septated (Figure 2), complex septated (Figure 3) and homogenously echogenic (Figure 4).^{11,12} Of these patterns, the anechoic pattern

is commonly encountered in clinical practice and is seen in both in exudative and transudative effusions.¹¹ It is also the pattern that is most easily identified. The remaining three sonographic patterns are highly suggestive of exudative effusions, of which some may be malignant in origin.

A complex septated pattern is defined by the presence of septations and/or fibrin strands within the pleural fluid and suggests an exudative effusion. A complex non-septated pattern is characterized by the presence of mobile echogenic particles or debris within the pleural fluid; it has also been referred to a swirl sign or plankton sign. This pattern has traditionally been thought to be only found in exudative pleural effusions, however a previous retrospective study found this pattern present in 55%

Table 1. Diagnostic Performance of Physical Exam, Chest Radiography and Ultrasound for the Diagnosis of Pleural Effusion

Physical Exam	Sensitivity	Specificity	+LR	-LR
Asymmetric Chest Expansion ⁸	74	91	8.1	0.29
Dullness ⁸	73	91	8.7	0.31
Imaging				
CXR ⁵	51	91	5.7	0.54
US ⁵	94	98	47	0.06

+LR = positive likelihood ratio; -LR = negative likelihood ratio; CXR = chest radiograph; US = ultrasound.

Figure 2. A sagittal ultrasound image of a complex non-septated pleural effusion (E) with a single echogenic particle (*), lung (L) and diaphragm (D) identified. It is worth noting that echogenic particles within pleural fluid are best seen on video and not in a still image.

Figure 3. A sagittal ultrasound image of a complex septated pleural effusion (E) as evidenced by the presence of a fibrin strand (*) tethering the lung to the diaphragm (D).

Figure 4. A sagittal ultrasound image of the superior right thorax demonstrating an anechoic pleural effusion (E) in addition to a homogenous echogenic pleural effusion (*).

of transudative pleural effusions.^{11,13} The presence of pleural fluid that is echogenic (bright) is referred to as a homogenous echogenic pattern and is most common in hemothorax (malignant or traumatic) and empyema.¹¹

Sonographic abnormalities of the pleura such as thickening or nodules are features of exudative and malignant pleural effusions. Pleural thickening over 3 mm suggests an exudative

effusion; whereas thickening over 1 cm is predominantly seen in malignant effusions.¹¹ Pleural nodules or masses are highly associated with malignant effusions, but can also be found in tuberculosis, pleural space fibrosis (fibrothorax) and asbestosis.¹⁴ In one study, ultrasound demonstrated good sensitivity and specificity (sensitivity 80%, specificity 84%) in differentiating malignant from non-malignant pleural effusions.¹⁵

As described above, features of an exudative and malignant effusions arise from the sonographic abnormalities of the pleural fluid and pleura. Depending on the abnormality present, a general internist can then refine the pre-test probability of an exudative or malignant effusion and adjust clinical management accordingly. While point of care ultrasound can find signs suggesting an exudative or malignant effusion, it should not be used as sole modality to exclude either condition.

Effusion Size and Procedural Guidance

Based on its appearance on ultrasound, the size of a pleural effusion can be visually described as small, moderate or large; alternatively the volume of a pleural effusion can be estimated using several mathematical models, the simplest of which involves measuring the distance from the visceral to the parietal pleura, referred to as the maximal expiratory interpleural distance (MEPD).^{16–18} The MEPD is greatest at the most dependent aspect of the collection and is therefore measured at the posterior axillary line in supine patients and at the mid-scapular line in upright patients. For a rapid estimate of pleural fluid volume at the bedside, a MEPD of 5 cm measured in the transverse plane predicts an effusion volume of greater than 500 mL with good sensitivity and moderate specificity (sensitivity 83–100%, specificity 67–90%).^{2,19}

Consensus guidelines support the use of ultrasound guidance for all diagnostic pleural aspirations due to improved success rate and decreased risk of complications.²⁰ The most common complication of thoracentesis is pneumothorax, occurring on average in 6% of procedures.³ Ultrasound guidance reduced the rate of pneumothorax by 16.3% in one study reviewing nearly twenty-thousand procedures, and by 43% in an earlier published systemic review and meta-analysis.^{3,4} The rate of hemorrhage was reduced by 38.7% with the use of ultrasound guidance.⁴

As indicated earlier, point of care ultrasound can be used to estimate the size of a pleural effusion, enabling identification of pleural effusions suitable for thoracentesis. Due to lower rates of complications, ultrasound guidance is essential when performing a diagnostic or therapeutic thoracentesis.

Limitations

Limitations of point of care can be divided into four areas: operator, access, and technical limitations. Point of care ultrasound, by nature is a heavily operator dependent technique that utilizes a non-comprehensive ultrasound examination to answer a specific clinical question. Operator inexperience with either image acquisition or interpretation can lead to false positive and negative findings, highlighting the need for quality assurance and adequate training. Comprehensive and detailed examination with chest radiographs or chest CT may uncover additional

abnormalities outside the area of examination. Access to and portability of ultrasound machines on a general medical ward may be challenging in contrast to the ubiquity of ultrasound machines in emergency rooms and intensive care units. Patient factors such as morbid obesity, chest bandages and positioning can lead to a non-diagnostic examination. Lastly, pleural and chest wall tumours, lymphoma and neurogenic tumours can mimic the appearance of a pleural effusion.²¹

Summary

The use of point of care ultrasound offers many advantages to the general internist who commonly diagnoses and manages pleural effusions as part of their practice. It provides superior diagnostic performance and additional diagnostic information when compared to physical exam or chest radiography alone, and is associated with increased procedural success and reduced rates of complications during thoracentesis.

Learning Pearls

- POCUS has superior sensitivity and specificity in detecting pleural effusions when compared to physical exam or chest radiography
- POCUS can detect features of exudative and malignant pleural effusions
- POCUS examination of the lungs in experienced hands can be performed and interpreted within minutes at the bedside
- POCUS guidance should be used for all diagnostic pleural aspirations due to improved success rate and decreased risk of complications

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