Introduction

Pneumonia is a common lung infection with significant morbidity and mortality. Currently, the diagnosis of pneumonia is made by patient history confirmed with chest radiograph or computed tomography. These modalities, however, have limitations including low accuracy, radiation exposure, and high cost. Lung ultrasound has become more prevalent in evaluating pulmonary conditions and has shown to be highly accurate in the diagnosis of pneumonia. The purpose of this review is to discuss sonographic findings associated with pneumonia, techniques used to obtain quality images, and the evidence in literature supporting the use of lung ultrasound in the diagnosis of pneumonia. Numerous studies including meta-analysis have shown lung ultrasound to be highly accurate compared to chest radiographs. With proper techniques, lung ultrasound may be a promising alternative to chest radiographs and chest tomography in the diagnosis of pneumonia.

Ultrasound findings in pneumonia

On ultrasound, identifying normal lung from pathology is first and foremost. Normal lung will display lung sliding and A lines [7, 12]. Lung sliding indicates sliding of the visceral against the parietal pleura. A lines are reverberation artifacts that are parallel to the pleural line caused by normal subpleural air in the alveoli. These findings are usually disturbed in pneumonia, characterized by less echogenic pleural line and reduced lung sliding [9].

Due to its non-invasiveness, relatively low cost, and bedside availability. While current guidelines do not recommend the use of ultrasound in the diagnosis of pneumonia, literature has shown that LUS is at least, if not more, accurate than chest radiographs [5, 7-11].

In this review, we will discuss sonographic findings associated with pneumonia, techniques used to obtain quality images, and the evidence in literature supporting the use of LUS in the diagnosis of pneumonia.

Use of Ultrasound for Diagnosis of Pneumonia in Adults, a Review

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Abstract

Pneumonia is a common lung infection with significant morbidity and mortality. Currently, the diagnosis of pneumonia is made by patient history confirmed with chest radiograph or computed tomography. These modalities, however, have limitations including low accuracy, radiation exposure, and high cost. Lung ultrasound has become more prevalent in evaluating pulmonary conditions and has shown to be highly accurate in the diagnosis of pneumonia. The purpose of this review is to discuss sonographic findings associated with pneumonia, techniques used to obtain quality images, and the evidence in literature supporting the use of lung ultrasound in the diagnosis of pneumonia. Numerous studies including meta-analysis have shown lung ultrasound to be highly accurate compared to chest radiographs. With proper techniques, lung ultrasound may be a promising alternative to chest radiographs and chest tomography in the diagnosis of pneumonia.
Multiple B lines are the sonographic sign of lung interstitial syndrome and their number increases with increased lung density [9, 12-15]. As disease progresses, B lines replace A lines; and as inflammation increases, more fluid fills the alveoli, and the lung appears more homogenous, resembling a solid parenchyma. On ultrasound, this may appear liver or spleen like [12-14]. While B lines alone are highly nonspecific, and even normal lungs can display a small number of B lines, clinical context and physical findings in conjunction with findings of B lines may suggest early pneumonia [9, 13].

Air bronchograms, air trapped in small airways within a consolidation, can be visualized on ultrasound as hyperechoic branching lines and dots within a hypoechoic area. Found in 70-97% cases, air bronchograms are a specific indicator of pneumonia [9]. Dynamic bronchograms, air bronchograms that move with respiration, are almost pathognomonic for pneumonia. These are especially useful in differentiating from obstructive atelectasis [7, 9, 13, 17].

Lung abscesses, particularly those in the periphery, abutting the pleura, are also detectable by LUS. They appear as rounded or irregular hypo-echoic lesions with outer margins [18, 19]. More so, color Doppler ultrasound has shown to be extremely useful in differentiating lung abscess and empyema, an important distinction that warrants different treatment plans [20]. Ultrasound is a valuable tool for the identification of pleural effusion, which is commonly present in patients with pneumonia. Additionally, ultrasonography features help determine the nature of a pleural effusion. For instance, in a study that included 320 patients, pleural effusion was classified into anechoic, complex nonseptated, complex septated, and homogeneously echogenic. Anechoic effusion included both transudates and exudates. A homogeneously echogenic effusion represented either empyema or hemothorax [21]. The use of ultrasound for guidance of thoracentesis is currently standard-of-care.

Evidence

Over the last few years, numerous studies including meta-analysis reports show promising results for LUS in diagnosing pneumonia. Two meta-analysis studies showed ultrasound to be superior to portable chest radiographs [5, 11]. Chavez et al conducted a meta-analysis of 10 studies which included 1172 patients showed. They showed that LUS has a 94% sensitivity and 96% specificity for the diagnosis of pneumonia in adults [5].

These results were similar to those of a previous study performed by Hu et al done in 2014 which also included children [10]. A more recent meta-analysis in 2017 by Alzahrani et al with over 2,500 patients (children and adults) showed overall sensitivity and specificity of 85% and 93%, respectively [7]. More so, Alzahrani reported positive likelihood ratio of 11.05 (3.76-32.50) and negative likelihood ratio of 0.08 (0.04-0.15). The largest multicenter European prospective study conducted by Reissig et al in 2012 with 362 patients showed 93% sensitivity and 97% specificity and even greater positive likelihood ratios of 40.5 (95% CI, 13.2-123.9) and 0.07 (95% CI, 0.04-0.11) for negative results [23]. In addition to high accuracy findings, a significantly shorter duration in obtaining LUS imaging compared to chest radiographs and CTs was also reported [5]. Additionally, a 2017 retrospective study by Brogi et al involving over 4000 patients in Italy showed that lung ultrasound was effective in reducing the number of chest radiographs and radiation exposure in the ICU, without affecting patient outcome [4]. These studies, however, are not without limitations. While chest computed tomography was used as ‘gold standard’ when comparing LUS vs chest radiographs for most studies, this was not for all cases [5, 23, 24].

LUS is highly operator and patient dependent. Obese patients with greater soft tissue composition and thicker ribcages may alter LUS findings. More so, LUS operator capabilities in performing LUS were not analyzed in many studies. However, studies have shown that minimal training can yield good proficiency in recognizing common LUS findings including pneumonia [25].
**Video 1** This video shows normal lung sliding as the visceral pleura rubs against the parietal pleura. ‘*’ indicates the pleural line and ‘R’ indicates rib and its shadow. [https://youtu.be/R7FTD3unFeg](https://youtu.be/R7FTD3unFeg)

**Video 2** This video shows lung consolidation indicated by ‘C’. With respiration, some B lines appear as well, which can be seen in early pneumonia. [https://youtu.be/oaJuF2LiOpA](https://youtu.be/oaJuF2LiOpA)
**Video 3** This video shows multiple B lines indicating interstitial syndrome. Here, pleural effusion is present. https://youtu.be/hb-7DjuPcy4

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**Video 4** This video shows empyema with multiple septations of the right lower lobe. https://youtu.be/BPmDTdp7yHY
Conclusion

LUS continues to become more prevalent in evaluating multiple pulmonary conditions today. Its use in diagnosing pneumonia has shown to be highly sensitive and specific in literature. Its ability to be utilized at bedside in real time, noninvasive nature, as well as lack of ionizing radiation make it an invaluable tool for rapid diagnosis of pneumonia. With proper techniques, LUS may be a promising alternative to chest radiographs and chest CT in the diagnosis of pneumonia.

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