

Diagnostic impact of integrating ultrasonography into routine practice in respiratory intensive care units

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Ultrasound (US) has received increasing interest from chest physicians in recent years especially in Respiratory ICU (RICU) settings. US examination is a valuable method in diagnosis of various thoracic conditions including pleural or pericardial effusion, empyema, pneumothorax, pulmonary embolism, and pneumonia. Its bedside application, easy to learn, short examination time, lower cost, guiding biopsy procedures, altering treatment plans and shortening ICU stay made US a valuable indispensable routine tool in daily management of critically ill RICU patients.

Introduction

Ultrasound has received increasing interest from chest physicians in recent years. Modern ultrasound devices are used easily, inexpensive, lightweight, and portable, which make them suitable for outpatient settings as well as bedside investigation of the severely ill patient. Lung ultrasonography is a useful tool in the ICU. It is superior in many respects to standard supine chest radiography, and its immediate availability allows the intensivists to rapidly assess the patient with acute respiratory failure at the bedside. It is easy to learn and straightforward in its bedside application; therefore, the intensivists should consider it as a key component of their skill set [1].

Ultrasound examination is a valuable method in diagnosis of various thoracic conditions including pleural or pericardial effusion, empyema, pneumothorax, pulmonary embolism, and pneumonia. Intensivists are able to provide better bedside care efficiently with a focused examination in critically ill patients. Thoracic ultrasound is mostly used to locate a target organ or a disease-specific condition and is often used as a complement to other imaging such as chest radiograph and computed tomography [2].

Advantages of chest sonography

Chest sonography has several advantages:

- (a) High sensitivity in detecting pleural lesions and differentiating pleural disease from parenchymal lesions (consolidation, abscess, or tumor);
- (b) Consolidation can be used as a sonographic window to visualize some centrally located lesions more clearly;

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- (c) Sonographically guided aspiration biopsy and thoracentesis can be performed accurately and easily;
- (d) Lower cost;
- (e) It is easily performed at bedside; and
- (f) Flexibility and short examination time as compared with compound scans.

These advantages make chest sonography a useful diagnostic tool with great potential in assisting decision making for and management of critically ill patients [3].

Ultrasound technology ranging from bulky machines to ultraportable pocket-size equipments is now available. For critical care echocardiography or transthoracic ultrasound examination, we prefer a laptop-size instrument mounted on a cart with different probes (linear, curvilinear, phased array) available. A brief description of the clinical application in thoracic ultrasound as a bedside test for critically ill patients in ICUs is as follows [4].

Pleural pathologies

Pleural effusion

It appears as an anechoic layer between the parietal and the visceral pleura. Movement of the atelectatic lung with respiratory cycle may be noticed through the pleural fluid. In supine position, pleural effusion is best witnessed from the lateral chest wall posterior to the midaxillary line with the probe pointed upward. In the upright or sitting patient, it can be located easily from the posterior or lateral chest wall. Transudates as a rule is anechoic, whereas exudates may appear anechoic or hyperechoic. Diffusely echogenic pleural effusion appearing as a 'snowstorm' usually represents empyema

containing protein or tissue debris. Echogenic septations or loculations confirm a complex empyema and are much better identified with ultrasound than with the computed tomography (Fig. 1). The differentiation between lung abscess and empyema is sometimes difficult because a hypoechoic center may be found in both [5].

Ultrasonographic types of pleural effusions

- (1) Homogeneously anechoic.
- (2) Complex nonseptated with heterogeneously hyperechoic spots (arrowed).
- (3) Complex septated with septa or fibrin strands (arrowed).
- (4) Homogeneously echogenic.

Pneumothorax

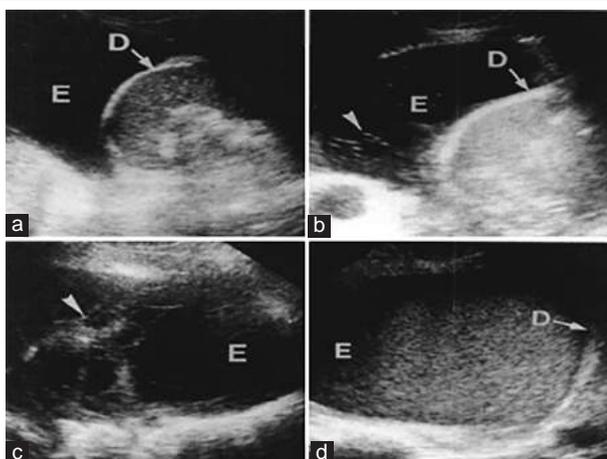
Air localized within the pleural cavity collects in the nondependent part and is best identified in the supine position with the probe held perpendicularly on the anterior chest wall. The depth of the pneumothorax cannot be determined. A pneumothorax is usually diagnosed by the absence of normal pleural gliding sign (movement of parietal pleura on the visceral pleura) and B-lines and the presence of exaggerated A-lines (an artifact produced by reflection of sound at the chest wall–air interface). M-mode is of additional help. Operator experience is crucial to analyze these artifacts [2] (Fig. 2).

A-lines

Hydropneumothorax

Hydropneumothorax can also be identified. A hemothorax may have hypoechoic or echogenic regions, occasionally with dependent layering of blood. Pleural thickening seen in fibrosis or empyema appears

Fig. 1



Ultrasonographic Types of Pleural Effusions. (a) Homogeneously anechoic. (b) Complex non-septated with heterogeneously hyperechoic spots (arrowed). (c) Complex septated with septa or fibrin strands (arrowed). (d) Homogeneously echogenic.

as a hypoechoic broadening of the pleura. Malignant effusions are usually anechoic but may become septated with repeated thoracentesis. Malignant pleural masses such as metastatic lesions or mesothelioma present as nodular pleural thickening and may accompany a pleural effusion [5].

Pleural thickening

Pleural thickening can be defined as a focal lesion arising from the visceral or parietal pleura that is greater than 3 mm in width with or without an irregular margin. It appears as broadening of the pleura and does not exhibit a fluid color sign or display movement relative to the chest wall [2] (Fig. 3).

Pleural tumors

The gliding sign identifies structures at the interface of the parietal and visceral pleurae. A subpleural mass will move with respiration against the parietal pleura; however, pleural sliding seen deeper to a tumor or mass will confirm its location within the chest wall. Absence of any movement at a particular location will provide evidence that both lung and chest wall are involved [2] (Fig. 4).

Pulmonary pathologies

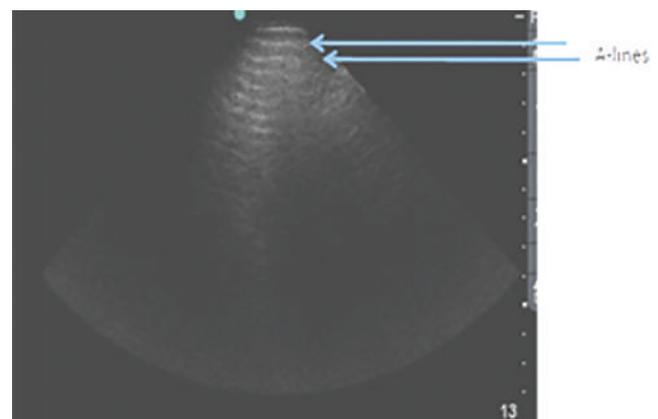
Pneumonia

Consolidated lung in contact with chest wall or contained in pleural effusion may appear as echogenic. Similar findings may be seen with pulmonary hemorrhage, bronchoalveolar carcinoma, or a lung infarct. Branching hyperechoic structures representing air bronchogram may be seen [2] (Fig. 5).

Atelectasis

Lung atelectasis is characterized by partial or complete absence of ventilation. Compression atelectasis is caused by voluminous pleural effusion. It is largely apneumatic and liver-like. The patient may develop triangular, hypoechoic consolidations shaped like

Fig. 2



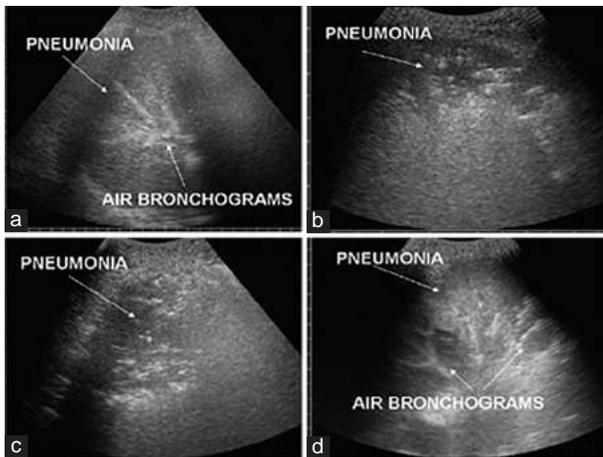
A-Lines.

Fig. 3



Pleural thickening (PT). Note the hypoechoic appearance with distal enhancement.

Fig. 5



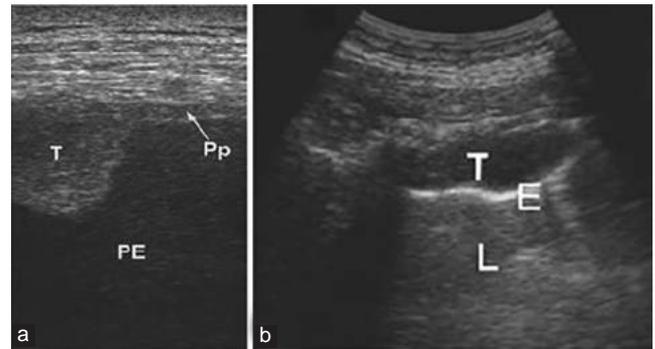
The echographic appearance of pneumonia. It is an irregular subpleural hypoechoic area with air bronchograms. (a, d) or many hyperechoic spots. (b, c). Pleural line is often hypoechoic.

a wedge or a pointed cap and show blurred margins to ventilated lung parenchyma. The compression atelectasis is floating in the effusion like a waving hand. These are partial reventilated during inspiration and after puncture of effusion [6] (Fig. 6).

Interstitial syndrome

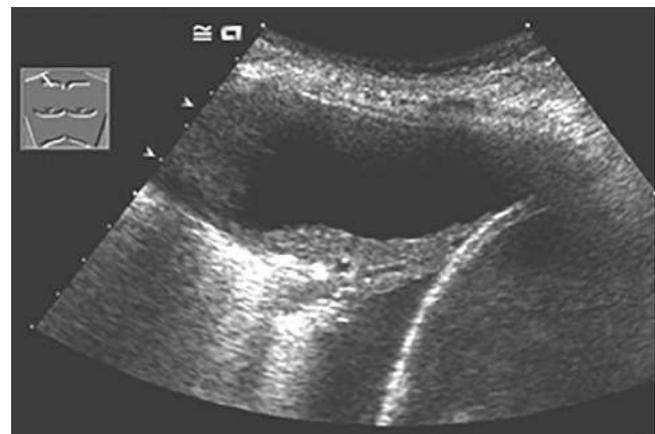
Using thoracic ultrasound for diagnosing the interstitial syndrome is one of the easiest ultrasound skills to learn. The interstitial lung involvement in heart failure, acute respiratory distress syndrome, fibrosis, and interstitial lung infections shares a similar sonographic pattern, extremely easy to be detected by bedside thoracic ultrasound in critically ill and emergency medicine patients. Although poorly specific, the sonographic diagnosis of interstitial syndrome is highly useful in many clinical scenarios [7].

Fig. 4



Two examples of the sonographic appearance of pleural tumours, one with a large pleural effusion. (a) and one without. (b) Note the posterior echo enhancement (E). PE: Pleural effusion; T: pleural tumour; Pp: parietal pleura; L: lung.

Fig. 6



Compression atelectasis: cap-like hypoechoic transformation of lung parenchyma.

Conclusion

Chest ultrasound is a beneficial tool for evaluation of the critically ill patients. Chest ultrasound is of great diagnostic impact among ICU patients especially with respect to helping the intensivist to reach the diagnosis. Chest ultrasound has a deep influence on the outcome of the patients through affecting their management plans and also helps in part in shortening their ICU staying days.

Acknowledgements

Conflicts of interest

None declared.

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