International Journal of Chemical and Biochemical Sciences
(ISSN 2226-9614)

Journal Home page: www.iscientific.org/Journal.html

An Overview on Lung Ultrasound Scoring System

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Abstract

Point-of-care lung ultrasound (LUS) is increasingly applied in the intensive care unit. Diagnostic applications for LUS in the NICU contain the diagnosis of many common pulmonary diseases (such as Respiratory distress syndrome, Transient tachypnea of the newborn, Meconium aspiration syndrome, Pneumonia, Pneumothorax, and Pleural effusion) which have been validated. In addition to being employed as a diagnostic tool in the classical sense of the term, recent studies have shown that the number and type of artifacts are associated with lung aeration. Based on this theory, over the last few years, LUS has also been used as a semi-quantitative method or as a "functional" tool. Scores have been proposed to monitor the progress of lung diseases and to decide whether or not to perform a specific treatment. The semi-quantitative LUS scores (LUSs) have been developed to predict the demand for surfactant therapy, the need of respiratory support and the progress of bronchopulmonary dysplasia. Given their ease of use, accuracy and lack of invasiveness, the use of LUSs is increasing in clinical practice. Therefore, this manuscript will review the application of LUSs in lung diseases.

Keywords: Lung, Ultrasound, Scoring System.

Review article
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1. Introduction

Lung ultrasound (LUS) has both as a diagnostic and monitoring tool for pulmonary diseases in the critically ill patients [1]. Lung ultrasound (LUS) has become increasingly used in both adult and pediatric populations, allowing the rapid evaluation of many lung and pleura diseases. This popularity is due to several advantages of the method such as the low cost, rapidity, lack of ionizing radiation, availability of bed side and repeat ability of the method [2]. Lung ultrasound was proposed as an imaging tool to guide and monitor mechanical ventilation [3]. It may help airway management: visualizing the orotracheal tube beside the trachea, it identifies esophageal intubation and, by visualizing bilateral sliding, it confirms tracheal intubation and excludes selective bronchial positioning [4]. LUS scores in the first 14 days of life can predict the development of bronchopulmonary dysplasia BPD [5]. In preterms, an LUS score based on B-lines, calculated in the first hours of life, can predict the need for intubation for respiratory support and surfactant administration [6]. A recent study in 2022 reported a new prediction method based on a modified lung ultrasound score. The investigators modified the classical lung ultrasound score by including sagittal scans of the liver and spleen using a convex probe from the lower end of the ribs [7]. These datapoints were potentially useful because chronic lung diseases (CLD) affect the posterior and lower part of the lung more than the anterior region [8].

1.1. Role of ultrasound in evaluation of chest diseases

Chest ultrasound can be used to:

• Identify and clarify the nature of pleural densities, pleural effusions and pleural thickening and detect pleural septations and other pleural abnormalities.

• LUS has a special role in pediatrics, including improved visualization of abnormalities in the thorax owing to the small thoracic diameters of children and the lack of ionizing radiation to produce diagnostic imaging results [9].

• LUS can diagnose secondary pneumonia as a complication of bronchiolitis to justify antibiotics administration [10].

• LUS has also been shown to be useful in differentiating between bacterial and viral pneumonia in children [11].

• Perioperative LUS can identify signs of pulmonary over circulation, such as pulmonary oedema and pleural fluid in children with congenital heart disease, with sensitivity and specificity of lung ultrasound (96% and 95%, respectively) [12].

• Assess diaphragmatic mobility and diaphragmatic motion abnormalities [13].

• Lung US also has a well-established role in guiding interventional procedures, including thoracentesis and biopsy, and has been shown to improve outcomes in these procedures by reducing complications (eg, pneumothorax) [14].

• Diagnosis of pulmonary parenchymal diseases like consolidation, atelectasis and tumor [15].

• Assessment of size, location, composition (solid or cystic) and blood supply of congenital lung deformities as cystic fibrosis [16].
• Investigation for the first time the relationship between patent ductus arteriosus (PDA) and diaphragmatic dysfunction, in neonates. Whereas significant patent ductus arteriosus was associated with lower diaphragmatic inspiratory velocity and a possible negative effect on diaphragmatic performance this finding might partially explain the affected infants' inability to successfully wean off invasive respiratory support [17].
• Diagnosis of TTN, highly compact B-lines in the inferior part and rare B-lines in the upper part [18].
• Meconium aspiration syndrome (MAS), MAS manifestations at LUS are similar to those of pneumonia, such as irregular sub pleural consolidations, compact B-lines, air bronchograms, even if they vary according to the severity [19].
• Assessment of respiratory distress syndrome (RDS), a frequent neonatal condition currently treated with endotracheal surfactant administration based on the degree of oxygen need in the first hours of life [20].
• Diagnosis of pulmonary hemorrhage of the newborn (PHN), a potentially life-threatening condition that usually occurs in the first week of life, Pleural line abnormalities and A-lines disappearance are present, possibly associated with bloody pleural effusions, pulmonary atelectasis, and alveolar–interstitial syndrome [21].

In recent years, the utility of LUS has been established for other neonatal and paediatric conditions: transient tachypnea of the newborn, pneumothorax, bronchopulmonary dysplasia, pneumonia, pleural effusion [22].

1.2. Normal lung ultrasound

Lung ultrasound can be performed with a low-frequency phased array or curvilinear probe. The bright hyperechoic pleural line is identified between ribs within intercostal spaces. During respiration, the two pleural lines glide over each other and is called the "Gliding sign" or sliding sign which will be lost in any condition which interferes with this movement as in pneumothorax and diffuse pleural thickening [23]. The normal ribs are hyperechoic in Ultrasonography with prominent acoustic shadows under it. About 0.5cm below the shadows of the ribs, the visceral and parietal pleura appear as an echogenic bright line named pleural lines [24]. The diaphragm appears as an echogenic line of 1 mm thick, above the liver and spleen, normal movement of the diaphragm should be seen during respiration. When the patient is sitting, the diaphragm is usually located inferior to the 9th rib [25]. The first step in performing lung ultrasound is localizing the "bat-sign" (Fig 1). This is an important landmark and must be visualized before analyzing any artifacts. The bat sign refers to the characteristic appearance of the pleural line along with the adjacent ribs.

The ribs resemble the wings of the bat, while the pleural line which lies about half a centimeter below the ribs resembles the body of the bat. It is seen when the probe is placed longitudinally on the chest wall. The bat sign is seen in all conditions except for subcutaneous emphysema, as the air in the subcutaneous tissues prevents adequate imaging of the structures underneath. Under normal conditions, the pleura appears as linear hyperechoic lines on ultrasound. Through dynamic observation, respiratory movements cause these pleural lines to slide back and forth, generating horizontal A-lines parallel to the pleural line [26]. However, when lung tissue undergoes pathological changes, such as the formation of inflammatory exudates and residual gas below the pleura, a perpendicular B-line artifact appears upon ultrasound beam interception [27]. The presence of B-lines signifies impaired lung tissue, reduced air content, and increased water content in the respective area [28].

1.2.1. Five basic imaging findings must be recognized

a) Lung sliding: Lung sliding seen on the M (motion) mode images appears as the sea-shore sign in which the pleura and the overlying structures appear as horizontal echogenic lines, while the underlying lung gives a grainy/sandy appearance [29]. The stratified appearance above the pleural line is due to the motionless chest wall (sea waves); whereas below the pleural line, the movement of the lung shows a sandy pattern (the shore) Miller A. [30]. A lines: Horizontal, hyperechogenic lines parallel to the pleural line. These lines are commonly seen in healthy individuals and may be erased (by B lines) [31].
b) B lines: Hyperechogenic lines that are perpendicular to the pleura and arising from the pleural line. These lines move with lung sliding [32].
c) Consolidation: Density of lung resembling solid tissue, referred to as "hepatization." Tiny, branching, hyperechoic "air bronchograms" might be evident within the consolidated lung.
d) Pleural effusion: Presents as separation of the visceral pleural and parietal pleural lines by anechoic fluid, result in motion of the visceral pleura toward the parietal pleura with each respiratory cycle.

All lung regions were scored on the presence of an abnormal pleural line, subpleural consolidations, dynamic air bronchograms and pleural effusions (1 when present and 0 when absent). Lung regions that were unable to scan or score (i.e., because of wounds, chest drains, or subcutaneous emphysema) were complemented by the mean LUS aeration score of other lung regions of the respective hemithorax [33]. In children, the posterior areas were found to be more sensitive more than the anterior and lateral areas in the diagnosis of effusion and atelectasis [9].

1.3. Advantages of ultrasound

• Lung ultrasound is radiation-free, low-cost, rapid, and portable.
• LUS may have higher sensitivity and similar specificity for detection of pleural effusion, pneumonia, pneumothorax, and pulmonary edema, compared with chest radiography [34].
• Critical care providers have adopted the bedside LUS in emergency (BLUE) protocol as a standardized approach to LUS in the ICU.
• Many practitioners have advocated for regular use of LUS in ICU to decrease use of chest radiography, which associated with increased cost and nontrivial cumulative radiation exposure (especially in pediatric patients).
• LUS has a special role in pediatrics, including improved visualization of abnormalities in the thorax owing to the small thoracic diameters of children and the lack of ionizing radiation to produce diagnostic imaging results.

1.4. Disadvantages of ultrasound

• Lung ultrasound is operator dependent, and its quality varies by practitioner [34].

• LUS needs more time to perform the examination compared with chest radiography. Complete LUS can take 20 minutes to perform, whereas chest radiography can be completed in a few minutes.

• For a complete examination of the deeper thoracic structures, chest radiography and/or CT imaging are preferred.

• In the ICU, LUS is more limited in evaluating lines and tubes compared with chest radiography.

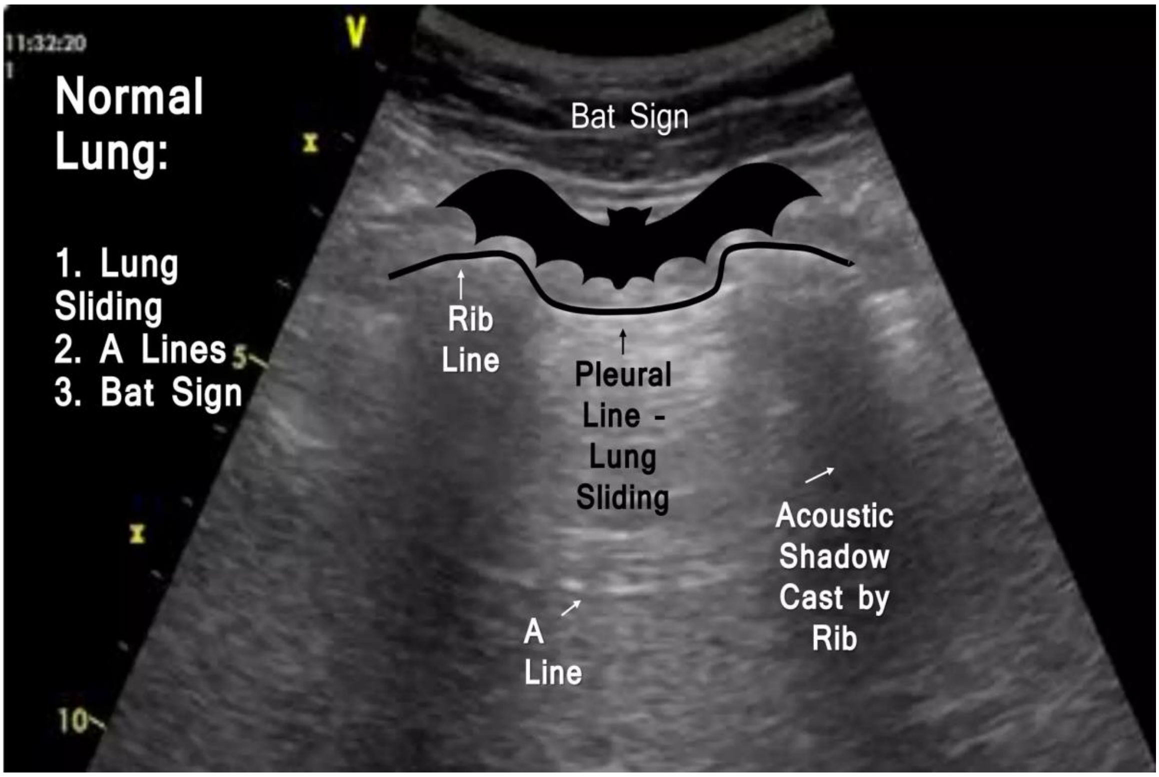

Figure 1. Bat sign

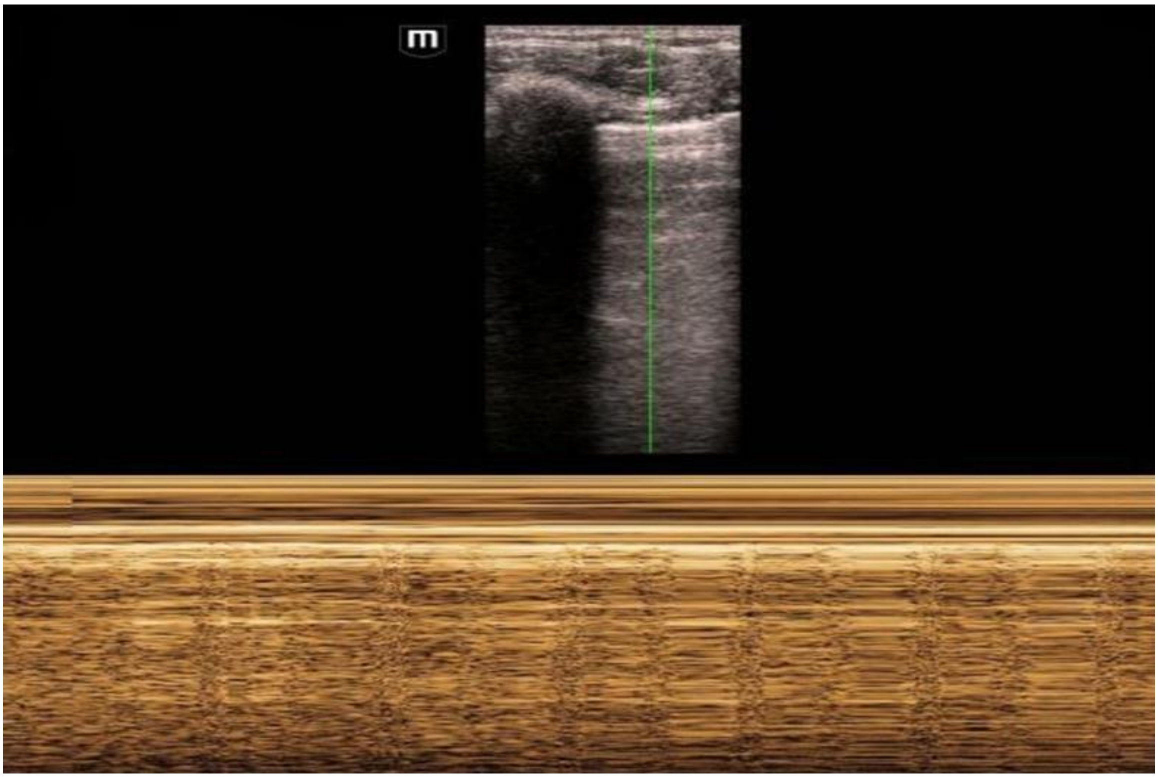

Figure 2. Seashore sign (M-mode) the yellow portion shows the flat, unmoving chest wall, while the grainy portion shows pleural movement. This is called the "Sandy Shore.

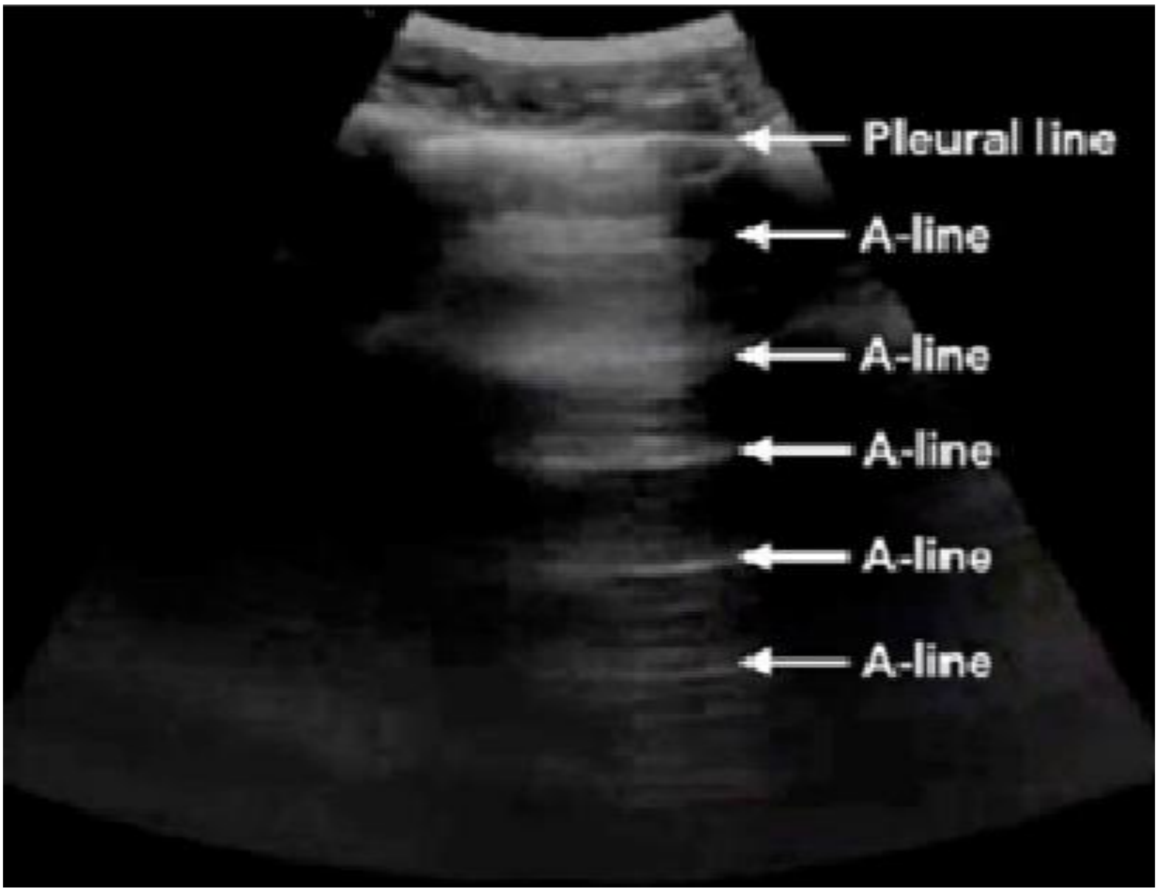

Figure 3. Lung ultrasound showing the pleural line and the artifact A-lines

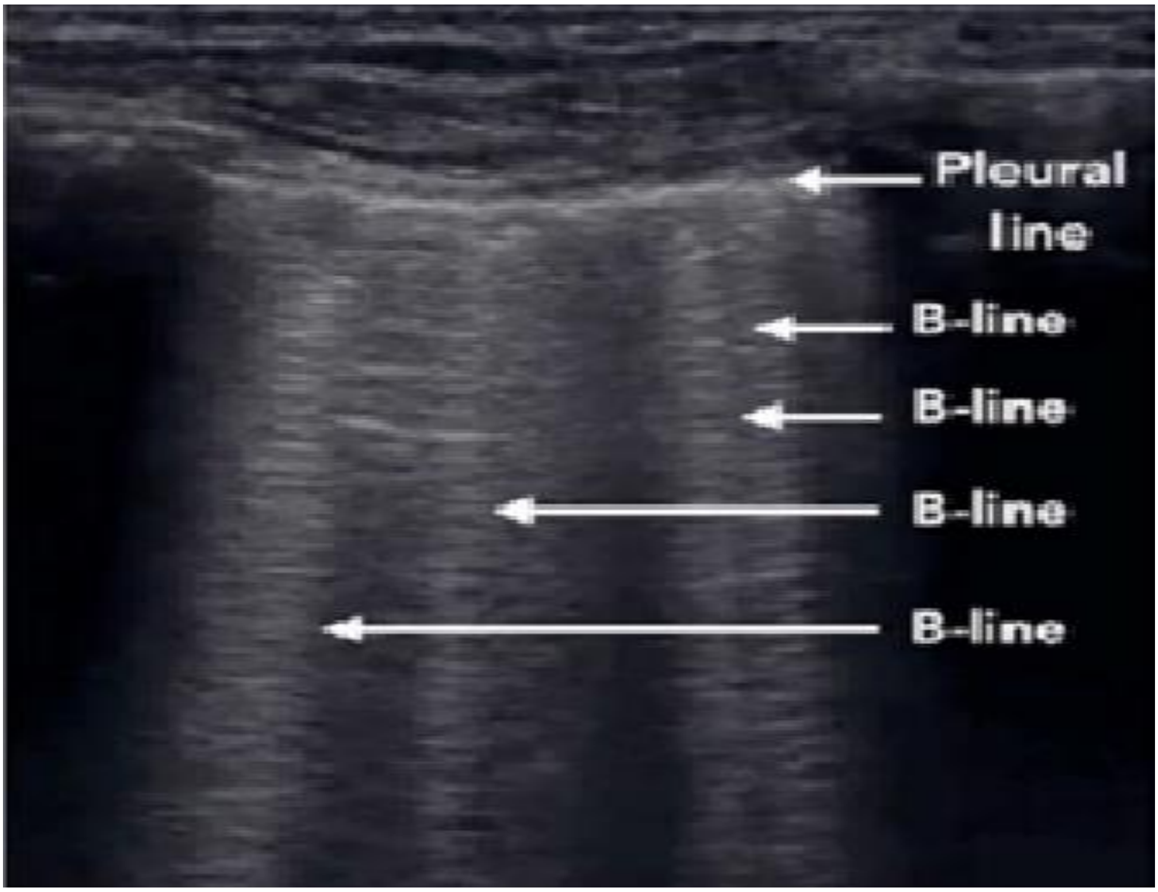

Figure 4. Lung ultrasound showing the pleural line and the artifact B-lines

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