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EDITORIAL

Lung ultrasound for diagnosis and management of ARDS

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Lung ultrasonography (LUS) is invaluable for diagnosing and managing adult respiratory distress syndrome (ARDS) because it is non-invasive, bedside, and widely available in both high- and low-resource settings. This article summarizes the technique and utility of LUS in ARDS patients.

LUS examination in ARDS

In ARDS patients, LUS patterns consist of bilateral B-lines and consolidations and can be differentiated from cardiogenic pulmonary edema by looking for pleural abnormalities or spared regions of lung (Fig. 1) [1, 2].

For assessment of ARDS, the operator should be proficient with the scanning technique and nomenclature of LUS (A/B-lines, consolidation, pleural line morphology, pleural effusion) (Fig. 1, supplemental video(s)). Lung injury in ARDS is heterogeneous; therefore, the examination should include the posterior thorax. The dependent zones is challenging in the supine critically ill patient and may require a team effort. While identification of A-lines, B-lines, and consolidation is achieved with a phased array or curvilinear probe, a high-frequency linear probe is necessary to evaluate pleural line morphology. The scanning plane is usually orientated in longitudinal axis, typically visualizing a single intercostal space with ribs shadows on two sides of the acoustic window and the pleural line in between (bat sign). The alternative is an off-axis transversal approach, where the tomographic plane is rotated to be aligned between the ribs to track the pleural line; hence, no rib shadows are visible. This approach often yields a higher B-line count than the longitudinal method, as a longer length of pleural line is available for the count.

Several methods for scoring LUS results have been described in the literature (4–12 lung regions) (Fig. 1). The operator needs to consider the purpose of numerical scoring in ARDS, such as the widely used 12-region approach. Yet, a focused LUS exam may suffice depending on the indication.

LUS diagnosis of ARDS

The Kigali modification of the Berlin definition first proposed LUS criteria for ARDS, specifically designed for limited resource settings where access to imaging and ventilators is scarce [3]. With the Kigali modification, bilateral B-lines or consolidations on LUS were allowed to fulfil the imaging criteria for ARDS. In comparison to the gold standard computed tomography (CT) in high-resource settings, these criteria proved to be highly sensitive but with low to moderate specificity [4]. The Global definition for ARDS later adopted the LUS criteria from the Kigali definition [5].

A useful development is the LUS-ARDS score, a data-driven and externally validated method based on LUS-scores (Fig. 1) from both the left and right lungs combined with the identification of an abnormal pleural line in the antero-lateral regions. This method involves more complexity than the Kigali modification, but exhibits higher accuracy in diagnosing and excluding ARDS [4].

Assessment of pleural abnormalities is important to distinguish between ARDS and cardiogenic edema [1], though it can be challenging for novel operators. In such instances, integration of LUS with focused cardiac ultrasound can be considered.

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LUS for management of ARDS

The LUS-score (Fig. 1) allows the clinician to assess the severity of lung disease at hospital admission [6] and to monitor lung aeration on a daily basis. This is relevant in adult/pediatric patients supported by extra-corporeal membrane oxygenation where chest radiography is poorly informative and transportation for chest CT is difficult [7]. A progressive reduction of the LUS-score corresponds to lung recovery and is observed in patients with better outcome [7, 8]. An unexpected increase may correspond to progression of the ARDS or supervening infection [9]. In this case, the visualization of a linear-arborescent dynamic air bronchogram within a consolidation is highly specific for ventilator-associated pneumonia [10]. Early ultrasound diagnosis and antibiotic therapy improve patients' outcome; LUS-score variations after one week of antibiotics correlate well with quantitative CT [11].

LUS has the potential to classify subphenotypes of ARDS which may be helpful to better target treatment in individual patients. In the early 2000's, two ARDS subphenotypes were identified based on CT assessment of lung morphology: a 'non-focal' subphenotype characterized by diffuse and patchy aeration loss that responded favorably to recruitment maneuvers and a 'focal' subphenotype with mostly dorsal-inferior consolidations that showed overinflation with high positive end-expiratory pressure (PEEP) titration and/or recruitment maneuvers and, therefore, had an indication for prone positioning [12]. The LIVE study revealed the potential of morphology-guided mechanical ventilation to enhance outcomes in ARDS patients [12]. This study mostly relied on chest radiography, resulting in substantial misclassification of the pattern of ARDS due to problems with interobserver variability. An attractive alternative to chest radiography

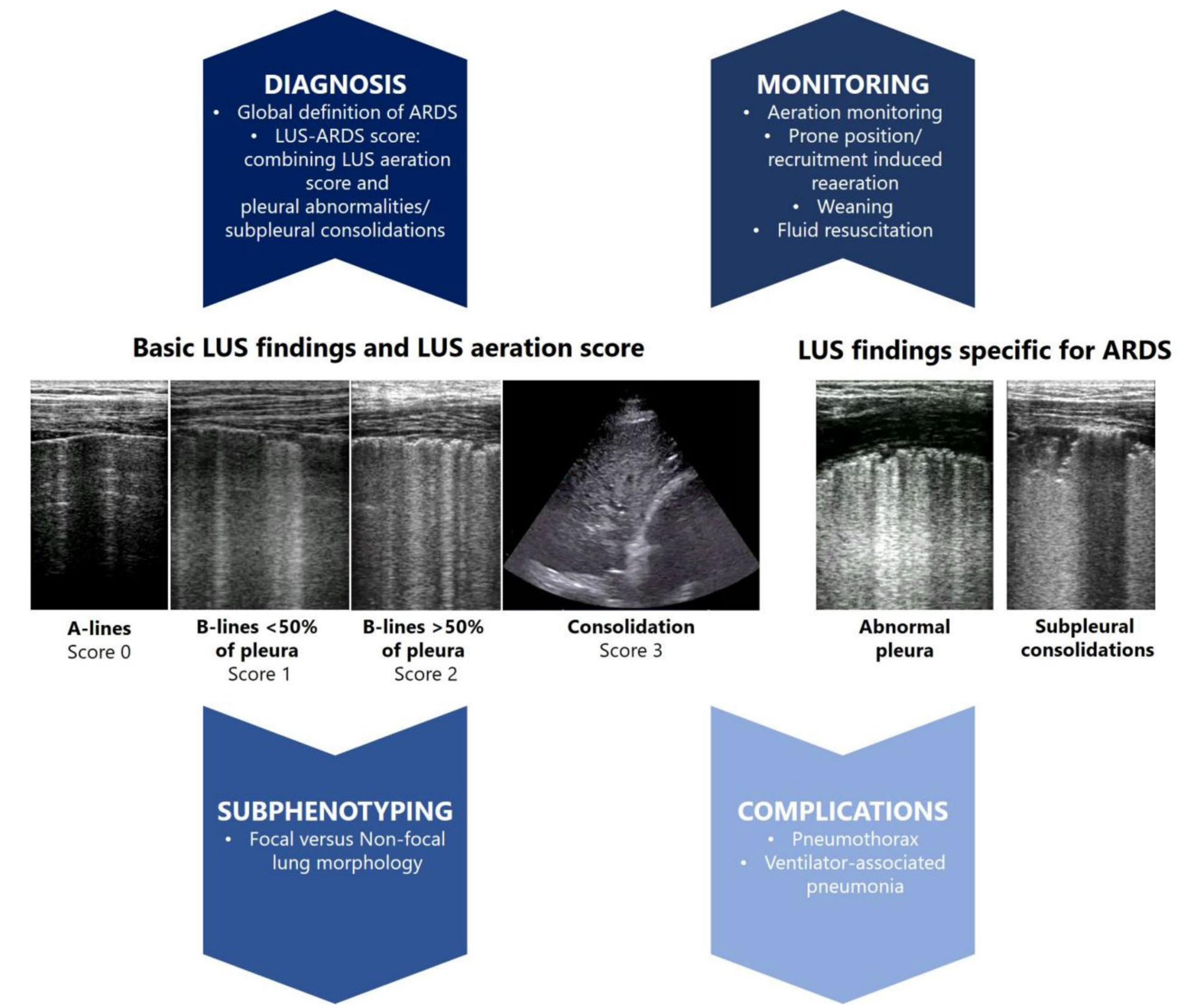

Fig. 1 Lung ultrasound for diagnosis, monitoring, subphenotyping and detection of complications in ARDS

would be the use of LUS, as it can accurately classify lung morphology compared to CT. The anterior LUS regions are most useful for classification for determination of morphology which is convenient, as these are easily accessible [13].

The LUS-score detects variations in regional and global lung aeration and is used to track response to treatment and respiratory management in patients with ARDS [14]. After recruitment maneuvers and PEEP titration, reaeration is mainly observed in anterior fields, with significant correlation with pressure–volume curves. The effects of prone position are mainly detected in posterior fields. Mechanical ventilation complications, such as pneumothorax, can be ruled out by visualization of lung sliding, lung pulse, or any B-line/consolidation. Conversely, visualization of a lung point is highly specific for pneumothorax. In ARDS patients with hemodynamic instability requiring fluid resuscitation, an increase in LUS-score is an early marker of increased extra-vascular lung water.

With improvement of ARDS, LUS has utility for predicting the success of extubation following a spontaneous breathing trial (SBT) [15]. Worsening of the LUS-score between the beginning and the end of the SBT predicts failure of extubation, i.e., progressive lung deaeration during the SBT is associated with extubation failure. An increase in LUS-score during the SBT may be due to multiple mechanisms (heart failure, inadequate airway clearance, or inadequate respiratory muscular function), making LUS a useful tool for the identification of the patients at high risk of extubation failure, whatever the mechanism involved.

Take-home message

LUS is essential for diagnosing and managing ARDS due to its bedside accessibility and availability across different resource settings. It aids in diagnosis and monitoring of ARDS progression and treatment response, while also offering potential for subphenotyping.

Supplementary Information

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Declarations

Conflicts of interest

SM received fees for lectures by GE Healthcare in 2019.

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