My Approach to Lung Ultrasound to Evaluate Extravascular Lung Water

Como Eu Faço Ultrassom de Pulmão para Avaliar Congestão

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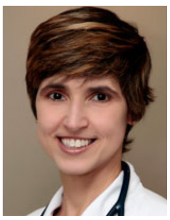

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Introduction

A clinical history, physical examination, and focused ultrasound can accelerate the appropriate diagnosis and treatment of patients with progressive or acute dyspnea.[1] Extravascular lung water (EVLW) is easily detected with lung ultrasound (LUS). Pivetta et al.[2] reported excellent accuracy detecting EVLW by clinical evaluation and by the presence of "B" lines on LUS heigher than B natriuretic peptide dosage.

The usefulness of LUS for intensive care unit patients was described in the 1980s, later than that of other ultrasound modalities.[3] LUS is useful not only for diagnosing EVLW but also for risk stratification in myocardial infarction[4] and acute congestive heart failure (CHF).[5]

Echocardiologists can easily learn this technique, which requires moving the transducer only a few centimeters from the usual accustic window used in echocardiography.

My approach to the technique

Equipment and transducers

Simple and hand-held ultrasound equipment can obtain adequate LUS images. If the equipment has no lung presets, the abdominal preset is most appropriate due to its higher persistence. However, the adult cardiac preset can be used without losing information despite its reduced persistence.

Three types of transducers can be used for LUS: 5-MHz convex, 3–5-MHz sectorial, and 5–12-MHz linear, the latter specifically to better assess the pleural line and slip. The sector transducer is most commonly used by echocardiologists due to ease of use and its narrow surface, which facilitates its transverse or longitudinal placement in the intercostal spaces.[6] The transducer can be used perpendicularly to the rib cage for rib visualization above and below the intercostal space. The ribs generate acoustic shadows that form an image called the bat sign (Figure 1).

Patient positioning and LUS protocols

LUS can be performed with the patient in supine or seated position. Air-predominant structures will be positioned more apically and anteriorly (such as air trapped in a pneumothorax), while fluids will be located more inferiorly and posteriorly (as in pleural effusion). Thus, the patient should be kept at a 30–45 degree chest inclination for the assessment of pleural effusion.[7]

The Bedside Lung Ultrasound in Emergency (BLUE) protocol, schematically described in Figure 2A, enables a more systematic chest evaluation.[8] This protocol divides the anterior region of the chest into eight segments from the right and left anterior axillary line. Each segment should be evaluated for the presence of the pulmonary artifact patterns described below. In addition to these eight anterior quadrants, the right and left costophrenic space region in the posterior axillary line should be evaluated for pleural effusion (Figure 2B).

LUS findings

Normal findings

Pleural line

The pleural line is a more superficial hyperechogenic structure that is actually the only normal lung image finding that is not an artifact. This line slides (between the parietal and visceral pleura) with respiratory movements. The absence of this movement may indicate pneumothorax which is beyond the scope of this article (Figure 1).[9]

A lines

The presence of air in the lung prevents proper ultrasound imaging. Thus, aerated lungs result in no interpretable

Keywords

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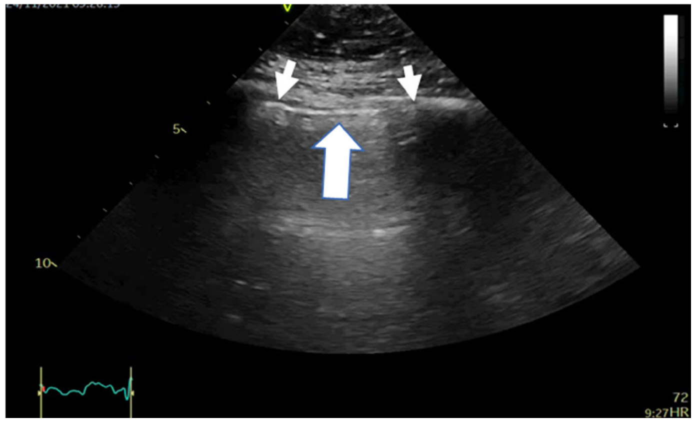
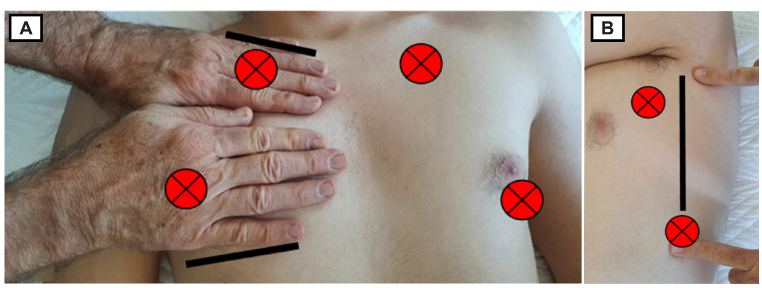


Source: Internal archive of the Echocardiography Department of Dante Pazzanese Cardiology Institute.

Figure 1 – *Lung ultrasound image with the transducer in the longitudinal position. Larger arrow, pleural line; smaller arrows, acoustic shadow of the rib called the bat sign.*



Source: Image produced by Dr. Maria Estefânia Bosco Otto based on information from several sources.[6,8–10]

Figure 2 – *Schematic representation of the Bedside Lung Ultrasound in Emergency (BLUE) protocol. A. Anterior chest analysis; B. Costophrenic sinus analysis using the posterior axillary line as a reference. A, B: Model to locate the points to be evaluated by lung ultrasound (LUS) using the BLUE protocol. Figure A: Using both hands on the patient's hemithorax with the superior little finger just below the clavicle (black line above the little finger) excluding the thumbs, and the inferior region of the other hand is positioned at the diaphragmatic line (black line). The "superior BLUE" point (red) is in the middle of the superior hand. The "inferior BLUE" point is in the middle of the inferior palm. These four points follow the anatomy of the lung and avoid the cardiac area. Figure B: The costophrenic sinus region point (red) is constructed from the horizontal line continuing the inferior BLUE point and the vertical line continuing the posterior axillary line (black). A superior point can be added between the posterior and anterior axillary line on the upper thorax floor. Thus, we will have four points in each hemithorax. This is a suggestion of a standardized location, but depending on the patient's anatomy and size of the cardiac area, adaptations can be made to obtain the pulmonary window.*

ultrasound findings. However, the hyperechogenic pleural line causes part of the ultrasound to reflect back to the transducer and another part to propagate in the aerated lung, causing a reverberation phenomenon with several equidistant "A" or pleural lines. This normal finding is called the "A" pattern and is more visible in thin patients or those with lung hyperinflation (emphysema) (Figure 3A).[9]

Abnormal findings

B lines

As the air content of the lung parenchyma is reduced, the density of the lung increases due to the increased presence of EVLW, exudate, transudate (in edema), collagen, or blood. Increased parenchymal density leads to contrast between lung structures, which now contain water in addition to air, and the ultrasound wave can be repeatedly reflected at deeper points from the pleura, creating vertical reverberation artifacts extending through the entire ultrasound accustic window depth. These artifacts are called "B" lines or comet tails. B lines move along the pleural line following its sliding with breathing. The number of B lines increases with increasing EVLW volume. A diagnosis of increased EVLW in a chest quadrant is significant in the presence of more than two B lines, being bilaterally considered significant EVLW by the BLUE protocol if four quadrants present more than two B lines (Figure 3B).[9] Sometimes B lines coalesce, forming a gray or white lung pattern that hinders A line visualization (Figure 3C).[9,10]

Consolidation

Other findings such as consolidation and air bronchograms reflect the presence of a pulmonary process with increased extravascular fluid. These findings are common in pulmonary embolism, bacterial or viral pneumonia, and atelectasis (Figure 3D).[9]

Search for pleural effusion

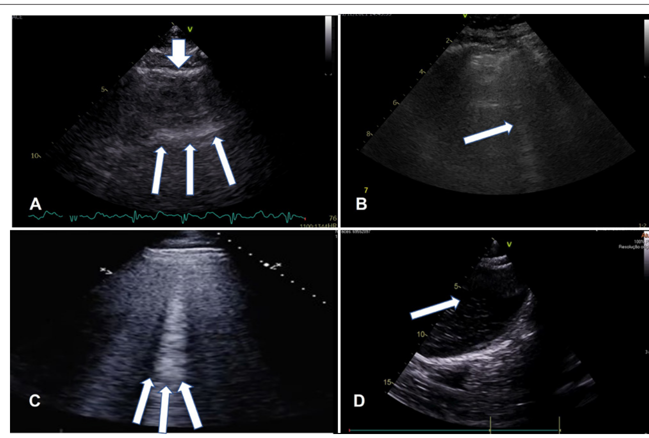
LUS is a sensitive tool for detecting pleural effusion. It can detect effusion volumes of 20 ml, while a chest X-ray detects only volumes larger than 100 ml. Pleural effusion detection should include a bilateral costophrenic sinus analysis (Figures 2B, 4). Some authors recommend the use of formulas to evaluate pleural effusion volume. The most commonly used is the Balik formula, in which effusion volume (ml) = 20 × the greatest transversal distance containing the pleural effusion in millimeters.[7]

How to describe changes in a structured lung report

Figure 5 shows a sequential report model for the eight-segment BLUE protocol understanding of the findings clinician's understanding of the findings. It is essential to describe findings on the right and left sides of each segment using a table. For more extensive lung involvement, segmentation can be expanded to 12, 16, or 32 segments.[9,10] However, the eight-segment protocol is practical and adds important information for echocardiologists who use LUS as a complement to echocardiography.

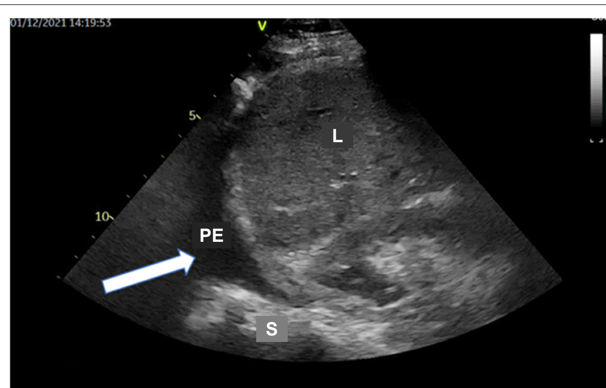
Conclusion

LUS was neglected for decades, but it has recently become indispensable for outpatient follow-up[11] or for the emergency treatment[5] of patients with dyspnea. LUS is fast and simple and provides crucial information. It is also of low cost and can be performed at the bedside using portable equipment. LUS is not a substitute for clinical examinations and should be considered in the context of the patient's history.



Source: Institute and the Cardiology and Transplant Institute of the Federal District.

Figure 3 – *Lung ultrasound findings in the parenchyma. Internal archive of the Echocardiography Department of Dante Pazzanese Cardiology. A. Lung ultrasound (LUS) quadrant. Thick arrow: pleural line; slin arrow: A line. B. LUS quadrant. Arrow: B line. C. LUS quadrant with coalescing B lines (arrows). It is not possible to differentiate A lines, only the pleural line. D. LUS quadrant showing consolidation and some air bronchograms (arrow).*



Source: Internal archive of the Echocardiography Department of Dante Pazzanese Cardiology Institute. L, liver; PE, pleural effusion (arrow); S, spine.

Figure 4 – *Costophrenic space with pleural effusion.*

Test indication:
Test technique:

Quadrant	Number of B lines	Quadrant	Number of B lines
D1		E1	
D2		E2	
D3		E3	
D4		E4	

Pleural effusion
Right costophrenic sinus:
Left costophrenic sinus:
Pleural effusion quantification by the Balik formula: _ mL

Conclusion: Uni-/bilateral presence of B lines in X quadrants

Figure 5 – *Essential report elements. Table with columns on the left with four quadrants on the right (D1–D4) and on the right with the four left quadrants (E1–E4).*

Authors' contributions

This is a review article, there was no data collection or statistical analysis. Otto MEB and Esmanhoto VA equitably reviewed the literature, provided the images, and wrote the manuscript.

Conflict of interest

The authors have declared that they have no conflict of interest.

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