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The Role of Thoracic Ultrasound in Pulmonary Emergency Cases

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Ultrasound, Thorax, Pulmonary Disorders

ABSTRACT
Pulmonary distress is a condition that requires a quick and accurate diagnosis to determine the appropriate medical intervention. Conventional radiological examinations, such as chest X-rays, often have limitations in emergency settings, particularly in the emergency department or ICU. In recent years, *thoracic ultrasound* (ultrasound) has become widely used as a point-of-care diagnostic tool because it is non-invasive, fast, portable, and radiation-free. This study aims to determine the role and benefits of *thoracic ultrasound* in establishing the diagnosis in patients with pulmonary disorders. This study employs qualitative research methods. Data collection was conducted by reviewing case report documents. The data collected were analyzed in three stages: data reduction, data presentation, and drawing conclusions. The results demonstrate that *thoracic ultrasound* examination is a highly effective diagnostic tool in managing cardiorespiratory emergencies. With high sensitivity and specificity, *thoracic ultrasound* can detect various lung conditions—such as pneumonia, pulmonary edema, pneumothorax, pleural effusion, and pulmonary embolism—more accurately than conventional radiography. The application of protocols such as BLUE, FALLS, and SESAME facilitates rapid and systematic diagnosis in patients presenting with acute respiratory failure or shock of unclear origin. Systematic and targeted *thoracic ultrasound* examinations, based on sonographic artifact patterns like B-lines, consolidation, or effusion, help accelerate clinical decision-making and improve treatment effectiveness in critical situations.

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INTRODUCTION

Thoracic ultrasound (ultrasound) is a vital diagnostic tool in managing emergency cases, especially in patients presenting with chest pain, respiratory symptoms, or shock. Compared to chest radiography, ultrasound offers higher sensitivity while maintaining good specificity. These advantages facilitate more accurate diagnoses, reduce false-positive results, and improve the efficiency of the diagnostic process, ultimately saving lives in emergency situations (Volpicelli et al., 2023; Interrigi et al., 2017; Rambhia et al., 2017).

Several protocols have been developed to optimize diagnosis in cardiorespiratory emergencies. One notable example is the *Bedside Lung Ultrasonography in Emergency* (*BLUE*) protocol, developed by Lichtenstein as an algorithm to diagnose dyspnea in patients with acute respiratory failure in the intensive care unit, achieving an accuracy rate of up to 90.5%. Additionally, the *Fluid Administration Limited by Sonography* (*FALLS*) protocol

focuses on managing acute circulatory failure, while the *Sequential Emergency Scanning Assessing Mechanism or Origin of Shock of Indistinct Cause* (*SESAME*) protocol aims to evaluate the underlying mechanism or cause of shock or hypovolemia of unclear etiology, particularly in cases such as heart attacks or cardiac arrest.

These protocols are designed to enhance the effectiveness of diagnosis and management in cardiorespiratory emergencies (Rambhia et al., 2017; Bekgoz et al., 2019; Lichtenstein, 2017). This review aims to provide a deeper understanding of the working principles and clinical applications of *thoracic ultrasound* based on protocols like *BLUE*, serving as a practical guide for medical personnel to accelerate diagnosis and treatment in critically ill patients.

Previous studies, including those by Volpicelli et al. (2023) and Interrigi et al. (2017), emphasize the advantages of *thoracic ultrasound* in diagnosing cardiorespiratory emergencies, highlighting its higher sensitivity over chest radiography and ability to reduce false positives. However, these studies mostly discuss the general benefits of ultrasound without detailed focus on specific protocols such as *BLUE* or *FALLS*, which optimize ultrasound use in emergency settings. Rambhia et al. (2017) explored various protocols like *BLUE* and *SESAME* but did not provide detailed analyses of how these protocols improve diagnostic accuracy in acute respiratory failure and shock.

The objective of this review is to explore and explain the clinical applications and benefits of *thoracic ultrasound* in diagnosing cardiorespiratory emergencies, particularly through protocols such as *BLUE*, *FALLS*, and *SESAME*. This research aims to enhance the efficiency of emergency medical procedures, enable quicker diagnoses, reduce unnecessary interventions, and ultimately improve patient outcomes in life-threatening conditions. It will serve as a valuable resource for emergency healthcare providers, especially in settings where rapid diagnosis is critical for saving lives.

METHOD

This study used qualitative research methods, a scientific approach aimed at understanding phenomena within their natural social context, emphasizing the interaction and communication between the researcher and the subject studied. This method involved collecting, analyzing, and interpreting non-numerical data to gain a deeper understanding of the meanings, experiences, or perspectives related to the phenomenon (Sari et al., 2022).

Data were collected through the review of case report documents, including medical records and supporting examination results of patients with pulmonary emergencies such as pneumothorax, pleural effusion, or pulmonary edema who underwent thoracic ultrasound examinations. The data were then analyzed in three stages: data reduction, involving filtering out irrelevant information and focusing on findings supporting the research objectives; data presentation, compiling information into narratives or tables to facilitate understanding and pattern identification; and drawing conclusions, by formulating key findings on the effectiveness of thoracic ultrasound in assisting rapid and accurate diagnosis and management of pulmonary emergencies. This approach provided a comprehensive understanding of the diagnostic role of thoracic ultrasound in emergency clinical practice.

RESULT AND DISCUSSION

The term ultrasound refers to a frequency of > 20 kHz. In sonography diagnostics, the frequencies used range from 1-20 MHz. Ultrasound works by using short sound waves that are transmitted into the body. The propagation speed of sound waves is constant for each type of network and is not affected by the frequency or wavelength. The denser the molecules in the network, the faster the speed of the sound waves. Sound waves transmitted into the body can undergo reflection, refraction or absorption. Reflection or backscatter occurs when waves meet surfaces between tissues that have different acoustic impedances. The greater the difference in acoustic impedance, the stronger the backscatter or reflection produced (Hertzberg, 2016). In assessing the picture of the lungs (B-lines), the ultrasound probe should be placed in the intercostal space. There are two main approaches to scanning: longitudinal and transverse. On longitudinal scans, the costae and their shadows are visible in the ultrasound results (Figure 1A), whereas on the transverse approach, a wider part of the pleura can be visualized without being disturbed by the costae shadows (Figure 1B). The main reference point to be considered is the pleural line which indicates lung sliding. Without a clear visualization of lung sliding, it is difficult to infer information regarding lung aeration (Gargani, 2019). The pulmonary ultrasound examination protocol includes five main locations for evaluation, as seen in figure 2.

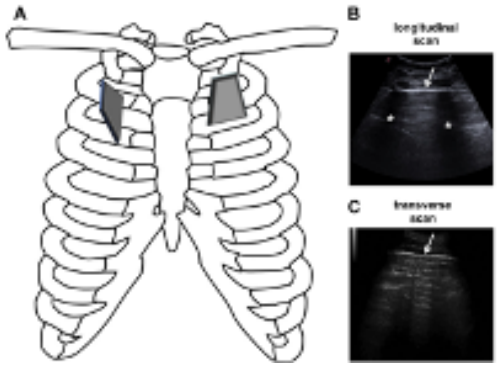

Figure 1. Different probe positions in lung scans. (A) A picture of the lungs with a probe placed. (B) Longitudinal approach, the costal shadow is marked with an asterisk mark. (C) The transverse approach, which allows for the visualization of a wider pleural line, is marked with a white arrow

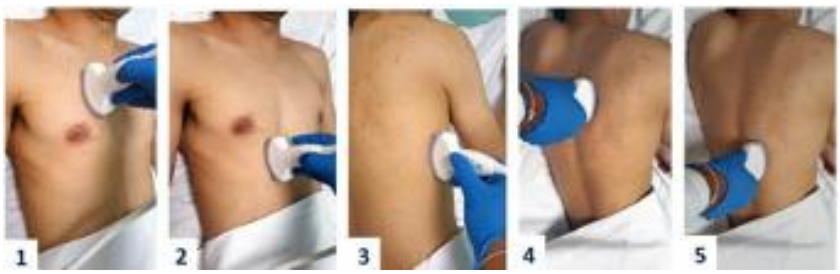

Figure 2. The thoracic ultrasound protocol involves five main examination points, namely (1) upper anterior thorax, (2) lower anterior thorax, (3) middle axillary line, (4) upper posterior thorax, and (5) lower posterior thorax. To obtain an optimal picture, the orientation of the probe sagitally and intercostally can be applied

The structure or tissues of the body have a different ability to reflect ultrasound waves, which is called echogenicity. Ecogenicity describes the ability of a network to reflect sound waves, where networks with high echogenicity appear white on the monitor, while low ones appear black. Based on their ecogenicity, structures can be classified into three categories: hyperecoic (white), hypooecoic (gray), and anekoic (black). The selection of transducers in thoracic ultrasound is an important aspect. High-frequency transducers (7.5–10 MHz) are ideal for visualizing structures close to the surface, such as pleural thickening, pleural masses, or subpleural lesions. In contrast, low-frequency transducers (2–5 MHz) are used to look at deeper structures, e.g. atelectasis and complex pleural effusion. The types of transducers are also diverse, such as linear arrays, which are suitable for surface structures; phased array, which is used for deep structures; and curvilinear arrays, which have convex surfaces and are suitable for extensive visualizations, such as massive pleural effusion or pulmonary examination through an abdominal approach (Hertzberg et al., 2016; Gargani, 2019).

The selection of probes depends on the need for network penetration. Probes with higher frequencies provide better image resolution, but the penetration is shallower, suitable for superficial structures such as the mass of the chest wall (3–6 cm). Meanwhile, convex probes with a frequency of 3.5–5 MHz are often used for lung ultrasound because they can penetrate tissues to a depth of 15–20 cm, albeit at a lower resolution (table 1) (Raheja et al., 2019).

Table 1. Choice of frequencies and types of probes for ultrasound

Frequency	Use
2.5 MHz to 5 MHz Curvilinear	Thoracic ultrasound (BLUE protocol), thoracocentesis, abdominal aortic aneurysm, deep abdominal ultrasound, obstetric and gynecological ultrasound, FAST scan
3.5 to 5.0 MHz Phased array	Echocardiogram and ultrasound of the lungs, thoracocentesis, FAST scan
6 MHz to 11 Linear arrays	Breast, thyroid, carotid artery, retinal scan, musculoskeletal, DVT, pleural mass, vascular ultrasound
12 to 15 MHz B scan probes	Eyeball

FAST: focused assessment with sonography for trauma, DVT: deep vein thrombosis

Description of normal thoracic ultrasound

Air is an obstacle to ultrasound examination, so imaging of air-filled organs was previously considered impossible. It is true that in normally ventilated lungs, ultrasound can only provide an indirect picture of the parenchyma of the lungs that is still informative. If the lungs are normally ventilated or overerated, only the pleura can be seen as a horizontal hyperechoic line that moves synchronously with breathing. This movement is called "lung sliding" and is a sonographic representation of respiratory movements (Rambhia et al., 2017; Gargani, 2019).

Understanding the anatomy of normal thoracic ultrasound begins with understanding the anatomy of the chest wall. As mentioned earlier, a high-frequency linear transducer will provide better definition of the intercostal muscles, the shadow of the costal bone, and the pleural line, often resulting in distinctive "bat-wing" markings. Below the pleural line, it is impossible to visualize the rest of the structure, as the high acoustic interaction between the air and the surrounding tissues causes the entire ultrasound wave to be reflected back. When air

content is reduced because the pulmonary interstitium or alveolar space is filled by transudates, exudates, blood, or other tissues, acoustic mismatches are also decreased and ultrasound waves can penetrate partially down the pleura. At this point, some hyperechoic vertical reverberation artifacts called B-lines (formerly known as "ultrasound lung comets") can be seen. Although the physical basis of this ultrasound is not yet fully understood, the main hypothesis is that in general, the less air in the lungs, the more B-lines are visible. When the air content is completely lost, as in consolidation, the pulmonary parenchyma can be seen immediately, which appears as a dense organ with echogenicity similar to that of the liver (figure 3) (Rambhia et al., 2017; Gargani, 2019; Nobile et al., 2024).

Thus, thoracic ultrasound can be considered a "densitometer" for the pulmonary parenchyma, which produces the following patterns:

a. Normal or overaerated lungs, visible as pleural lines without a significant B-line or consolidation underneath.
b. The lungs, which are partially unventilated, are visible as a variable number of B-lines (usually at least three B-lines at one scan site).
c. Completely unventilated lungs, seen as consolidation (Rambhia et al., 2017; Gargani, 2019).

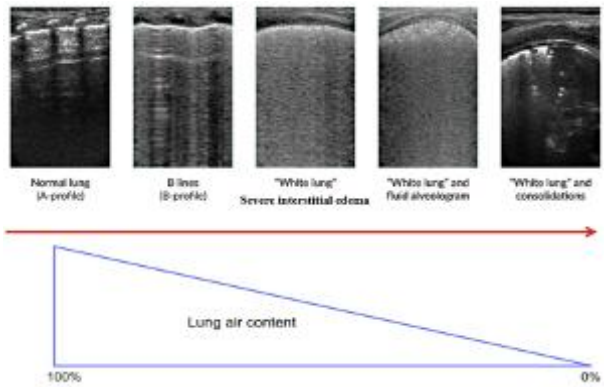

Figure 3. The physical basis of pulmonary ultrasound

The less air there is in the lungs, the easier it is to detect lung abnormalities using ultrasound. The concept of pulmonary ultrasound as a densitometer: different ultrasound patterns for different levels of lung aeration (Gargani, 2019; Nobile et al., 2024).

BLUE Protocol

The BLUE protocol, which is an ultrasound examination of the lungs at the patient's bed in an emergency situation, focuses on the immediate diagnosis of respiratory failure. This evaluation can reveal specific lung pathologies such as pneumonia, congestive heart failure, COPD, asthma, pulmonary embolism, and pneumothorax, and involves the recognition of certain signs and patterns that correlate with normal and pathological findings. The BLUE protocol describes standard points for examining the lungs: upper anterior thorax, lower anterior thorax, and posterolateral thorax, with an emphasis on following the contours and anatomy of the lungs (Rambhia et al., 2017).

In emergency situations, there are three points that are specifically defined. These BLUE points are determined by placing their hands on the patient's thorax to make it easier to determine the ultrasound field area (figure 4). There are three BLUE dots (Figure 3), two on the anterior chest wall (upper and lower BLUE dots) and one semi-posterior (posterolateral alveolar and/or pleural syndrome [PLAPS]). This allows the detection of PLAPS, i.e. consolidation and/or pleural effusion. Although these points are already standardized, they provide flexibility for operators. The first step in performing a pulmonary ultrasound is to identify the "bat-sign". These are important markers that should be visualized before analyzing other artifacts (Lichtenstein, 2017; Hensin et al., 2020; Murali et al., 2022).

The level of sensitivity and specificity of the ultrasound results obtained through the BLUE protocol based on the diagnosis established by the BLUE protocol has been proposed by Bekgoz et al., (2019), as shown in table 2.

Table 2. Sensitivity and specificity of ultrasound findings of the BLUE protocol according to the diagnosis of the BLUE protocol

Diagnosis	Ultrasound findings of the BLUE protocol	Sensitivitas (%) (95% CI)	Specificity (%) (95% CI)	Positive Predictive Value (%) (95% CI)	Negative Predictive Value (%) (95% CI)
Edema paru cardiogenics	Bilateral diffuse B-Line along with sliding lung	87 (79–93)	97 (94–98)	91 (84–95)	95 (93–97)
Pneumonia	Local PLAPS, AB, C, B', or B-Line profiles	82 (78–89)	98 (97–99)	96 (88–98)	94 (92–96)
Chronic obstructive pulmonary disease (COPD)/asthma	A-Line bilateral diffuse along with sliding lung	90 (90–87)	75 (68–80)	61 (56–66)	98 (95–99)
Pneumotoraks	The presence of A-Line without lung sliding findings, the absence of B-Line, and the presence of lung point findings	85 (42–99)	100 (99–100)	100 (99–100)	98 (95–99)
Emboli published	The presence of venous thrombosis on examination of the veins of the lower extremities along with bilateral diffuse A-Line	46,2 (19–74)	100 (99–100)	100 (99–100)	98 (96–99)

Figure 4. Locate the BLUE dot

(A) The radiologist first compares the size of his hand with the patient's hand, then places one hand just below the clavicle with the fingertips touching the midline. The "upper BLUE" dot is located at the base of the middle finger and ring finger. The other hand is placed just below the upper hand without including the thumb. The "bottom BLUE" dot is in the center of the lower palm, while the bottom edge of the little finger indicates the "phrenic line." (B) The point of "posterolateral alveolar and/or pleural syndrome (PLAPS)" is located at the intersection of the posterior elongation of the lower BLUE point and the posterior axillary line. This point is used to examine the posterior lung zone in critical patients who are in a supine or semi-reclining position. This examination is best performed using a small probe with a narrow footprint (C, D), which is held like holding a tennis racket, placed perpendicular to the PLAPSE point, and directed as far as possible towards the cranial to obtain a larger scanning area (Murali et al., 2022).

Lichtenstein developed an algorithm of approaches (figure 5) to deal with respiratory failure by simplifying the various knowledge that every physician must master, such as anatomy, physiology, pathophysiology, clinical signs, radiology, as well as other biological or paraclinical signs. This protocol is not intended to provide a 100% accurate diagnosis of acute dyspnea, but has been simplified with the aim of achieving an overall accuracy of more than 90% (90.5%) (Lichtenstein, 2017).

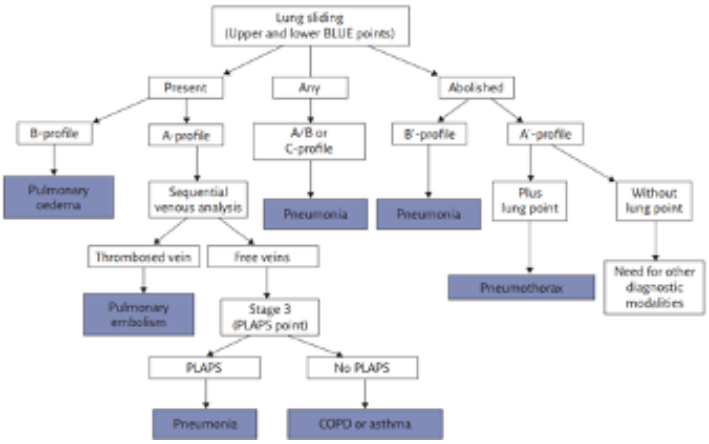

Figure 5. Diagnosis algorithm based on the BLUE protocol.

Picture of abnormal thoracic ultrasound in pulmonary turmoil

Pneumonia

Thoracic ultrasound is an excellent method for evaluating and monitoring known or suspected lung infections. Pneumonia has several imaging images depending on the extent of interstitial consolidation or involvement. The fully consolidated lungs appear a dense picture of the liver, known as hepatization (Figure 6). At consolidation, fluid or cells fill the alveolus, so that the normal A-line or air-filled lung becomes lost. If bronchogram water is present, it appears as a hyperechoic focus inside the consolidated lung (Figure 6, B). The interface between the consolidated abnormal lung and the normally ventilated lung can be recognized by an irregular hyperechoic line called a shred mark (Figure 6, C). Smaller infections may appear as focal hypoechoic subpleural areas. In early infection, a focal B-line may appear, indicating that the affected interstitial begins to thicken and/or become inflamed (Marini et al., 2021).

Color Doppler imaging is useful for the evaluation of lung abscesses and empisems. A pulmonary abscess indicates internal vascularization because there are residual parts of the pulmonary parenchyma that are necrotic to the lesion. In contrast, pleura-based empisema does not show internal flow. The gas focus in the group shows hyperecho and features twinkle artifacts on the US Doppler color. Complex conditions containing mixed areas of pneumonia, atelectasis, and pleural fluid are often better evaluated with pulmonary ultrasound than with chest radiography (Marini et al., 2021).

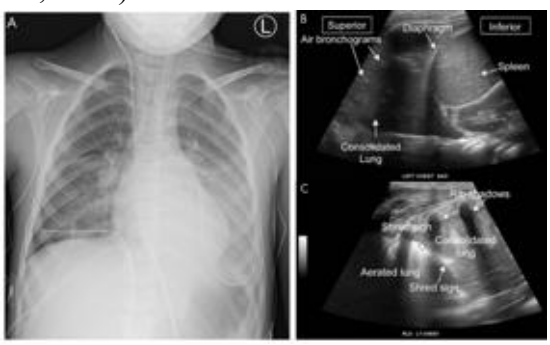

Figure 6. Pneumonia on the ultrasound of the lungs.

A, Anteroposterior chest radiography and B, C, ultrasound images of a 6-year-old patient with pneumonia. The lower lung on ultrasound looks similar to the appearance of the liver, which represents hepatization of the pulmonary parenchyma consistent with consolidation. B, The hyperechoic focus within the consolidation is the water bronchogram. C, Shred marks are irregular hyperechoic lines that separate the consolated lung and the ventilated lung (Marini et al., 2021).

ARDS (Acute Respiratory Distress Syndrome)

Acute Respiratory Distress Syndrome is an acute respiratory failure syndrome caused by non-cardiogenic pulmonary edema, which is the most severe stage of acute lung damage due to alveolar–capillary endothelial damage with fluid leakage from the intravascular compartment to the extravascular compartment. On lung ultrasound (LUS), multiple B-lines with irregular distribution were found alternating with hypopleural areas of consolidation accompanied by a bronchogram of water. The pleural line is also often irregular. In addition, the possibility to focus on healthy lung areas allows orientation in the comparative diagnosis of hydrostatic pulmonary edema (figure 7) (In Serafino et al., 2023).

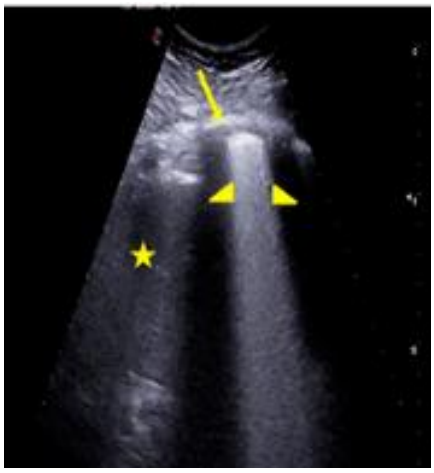

Figure 7. A 57-year-old female patient with acute respiratory failure due to interstitial pneumonia unrelated to SARS-CoV2 infection

Examination of the LUS performed after 5 days showed in the right central lung field and on the left side a compact appearance of the B-line (b, arrow) accompanied by several areas of parenchymal consolidation (b, star) with irregular pleural lines (b, arrow) indicating complications of ARDS, corresponding to a clinically resistant deterioration of therapy (Di Serafino et al., 2023).

Cardiogenic and Non-cardiogenic pulmonary edema

Pulmonary edema is defined as an increase in fluid in the interstitial and/or alveolar spaces of the pulmonary parenchyma. Acute cardiogenic edema and/or volume overload is usually accompanied by increased pulmonary venous pressure due to increased left diatric pressure and left ventricular end diastolic pressure. In LUS, several B-lines tend to fuse together (referred to as "white lungs") depending on the severity of the condition, which is also

associated with pleural effusion, inferior vena cava ectasia, and heart failure. Figure 8 shows an example of LUS in detecting cardiogenic pulmonary edema (Di Serafino et al., 2023).

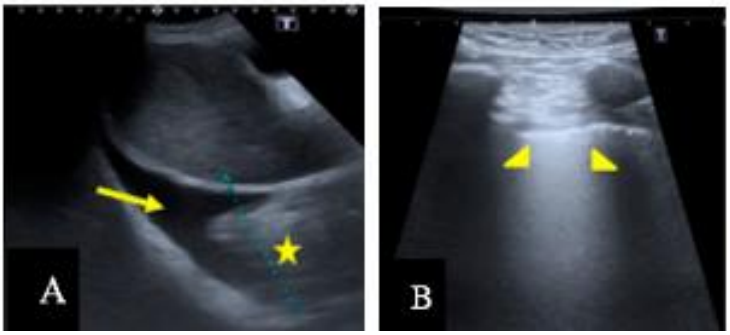

Figure 8. A 79-year-old male patient who was suspected of having pulmonary edema

(a,b) LUS integration shows at the base of the right lung (A) anecoic pleural effusion (A, arrow) accompanied by a consolidation area (A, star); evaluation of the right and left lungs (B) showed a compact appearance of the B-line in the explorable area of the lung in the intercostal space (B, arrow) (In Serafino et al., 2023).

Non-cardiogenic pulmonary edema is characterized by ultrasound findings that are not homogeneous throughout the thorax: the awakened area mixes with the area showing many B-lines fusing and consolidating (Figure 9) (Santangelo et al., 2023).

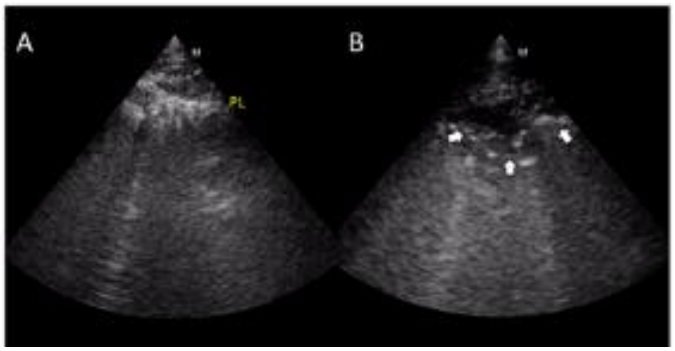

Figure 9. An ultrasound of the lungs that shows signs leading to a diagnosis of non-cardiogenic pulmonary edema. A. Thickened and irregular pleural line. B. Subpleural (arrow) consolidation (Santangelo et al., 2023).

Emboli Paru

The primary ultrasound criterion for diagnosing pulmonary embolism (PE) is the presence of triangular/wedge-shaped hypoechoic lesions or round, homogeneous, pleura-based lesions. One study observed that a diagnosis of EP can be suspected if there is at least one typical pleural-based/subpleural triangular or spherical hypooecoic lesion (with or without pleural effusion) found using thoracic ultrasound. Mathis et al., quoted from Bitar et al. (2022), diagnosed EP through thoracic ultrasound based on the following criteria: (1) confirmed EP, which is indicated by two or more typical triangular or spherical pleural-based lesions; (2) probable, which is indicated by a single typical lesion with pleural effusion; (3) possible, which is indicated by small lesions (Bitar et al., 2022). If associated with deep vein thrombosis (DVT) detected by ultrasound, this strongly leads to pulmonary embolism. In follow-up studies, a

combination of A-line, DVT, and subpleural consolidation (which corresponds to pulmonary infarction) allowed the diagnosis of pulmonary embolism with 90% sensitivity and 86% specificity in the emergency room (Mojoli et al., 2019). Pulmonary ultrasound performed as part of the evaluation for pulmonary edema showed two triangular-shaped subpleural hypochoic areas, with a base facing the pleura, indicating a possible pulmonary infarction (figure 10) (Bitar et al., 2022).

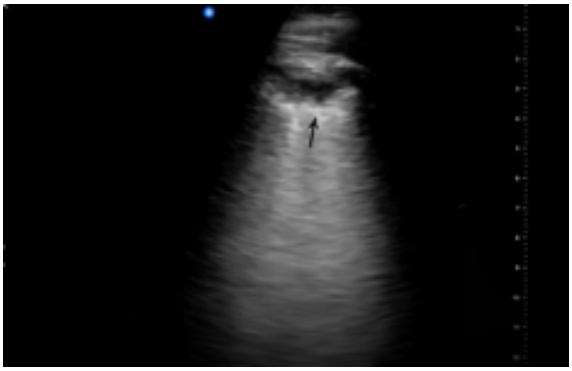

Figure 10. Ultrasound of the lung in the upper left anterior zone area using a curvilinear probe (5 MHz) showing triangular/iris shaped lesions or round, hypooecoic, homogeneous, pleura-based lesions (arrows) (Bitar et al., 2022).

Pneumotoraks

Pneumothorax separates the visceral and parietal pleura, eliminating the normal friction of the lungs between these layers on ultrasound of the lungs. The transition point between the pneumothorax and normal lungs is known as the pulmonary point. Pneumothorax can also be identified on M-mode ultrasound, a technique that depicts movement. In healthy lungs, the tissue above the pleural line remains still, with a smooth horizontal line on M-mode imaging. Under the pleura, pulmonary movement interrupts those lines, creating a finely disconnected granular or "sand" pattern. This normal pattern is called a seashore sign because it depicts the boundary between the stationary chest wall ("the sea") and the moving lungs ("sand"). The appearance of pneumothorax on this M-mode examination is called a bar code sign (Figure 11). The addition of color Doppler ultrasound can improve the detection of pneumothorax, as the color signal from the lungs is lost due to the air barrier in the pneumothorax (Marini et al., 2021).

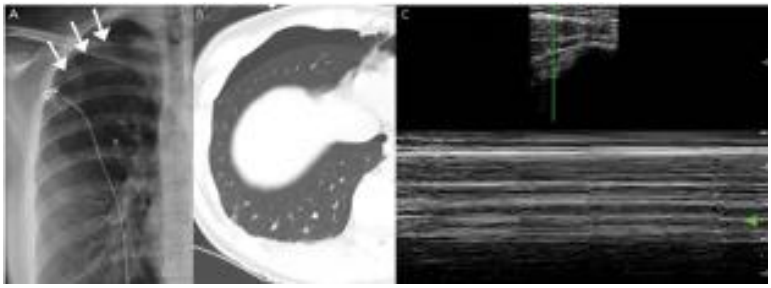

Figure 11. Pneumothorax on ultrasound of the lungs

A, Posteroanterior chest radiograph and B, axial CT image of spontaneous pneumothorax in a 26-year-old patient. C, The US M-mode image shows the bar code sign, which is the diagnosis for pneumothorax. The arrow shows the location of the pleural in the pneumothorax condition (Marini et al., 2021).

Pleura effusion

A simple effusion generally appears as an anechoic fluid in the back of the lung that hangs down. More complex pleural fluid buildups, including chronic effusion, malignant effusion, hemitorac, and empyema, have a more heterogeneous appearance on ultrasound, depending on the extent of debris, septation, and thickening of the pleura. Given the ability to visualize such details, pulmonary ultrasound is often better than conventional thoracic radiography for assessing complex pleural effusions and aids in interventional management. Pulmonary ultrasound can help identify areas that are localized for drainage or indicate a need for more aggressive therapy, including surgical lavage or the administration of tissue plasminogen activators. The large effusion creates an acoustic window that allows visualization of the vertebral body, which is also known as the spinal mark (Figure 12) (Marini et al., 2021).

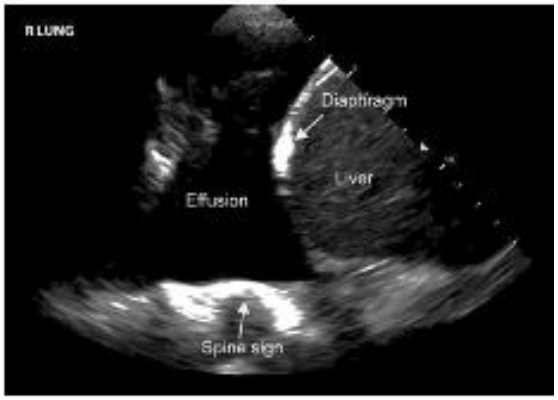

Figure 12. Pleural effusion on pulmonary ultrasound

US image of the lungs in patients with moderate-degree pleural effusion. The acoustic window created by effusion allows for the visualization of the spine (spine sign), as can be seen in this image. Normally, the vertebral corpus is not visible on ultrasound (Marini et al., 2021).

COPD and Asthma acute exacerbations

On thoracic ultrasound examination, acute exacerbations of COPD and asthma showed an A-profile, namely the presence of diffuse bilateral A-lines accompanied by lung sliding. Based on the BLUE protocol, if an A-profile is found, the results of venous blood vessel evaluation show the absence of thrombosis, and the absence of PLAPS, then the diagnosis tends to lead to COPD or acute exacerbated asthma (figure 13). In the expanded BLUE protocol, the physician performing the scan can expand the application of the BLUE protocol

as needed and utilize the clinical details that lead to pulmonary embolism, such as the use of contraceptive pills, chest pain, hemoptysis, interference with the ECG, positive D-dimer results, and so on, if pulmonary embolism is suspected. Similarly, auscultation to detect the presence of wheezing can be performed if there is a strong suspicion of COPD or asthma (Murali et al., 2022).

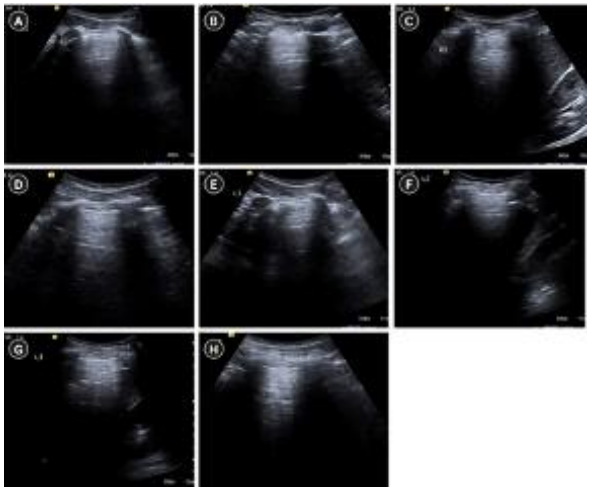

Figure 13. A-profile

Greyscale sagittal (A-H) ultrasound scans of eight lung zones on the bilateral anterolateral thoracic wall showed an A-profile (A-lines) with pulmonary friction and the absence of B-lines in a 30-year-old man who did not have a fever, with a history of chronic smoking, who came with complaints of shortness of breath, diagnosed as an exacerbation of chronic obstructive pulmonary disease/asthma via ultrasound (Murali et al., 2022).

CONCLUSION

Thoracic ultrasound is a crucial diagnostic tool in managing cardiorespiratory emergencies due to its high sensitivity and specificity, outperforming conventional radiography in detecting lung conditions like pneumonia, pulmonary edema, pulmonary embolism, pneumothorax, and pleural effusion. Established protocols such as BLUE, FALLS, and SESAME guide systematic examinations, enhancing rapid diagnosis in critical cases like acute respiratory failure or shock of unclear origin. By interpreting characteristic ultrasound artifacts and pulmonary aeration changes, thoracic ultrasound enables precise and timely clinical decision-making, thus improving emergency treatment outcomes. Future research should focus on validating and refining these protocols across diverse patient populations and clinical settings to further optimize diagnostic accuracy and protocol-driven interventions in emergency care.

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