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Lung Ultrasound in Critical Care and Internal Medicine: Evidence-Based Recommendations

Lednev Montorio*

Department of Rheumatology and Internal Diseases, Medical University of Lodz, 90-549 Lodz, Poland

Introduction

Lung Ultrasound (LUS) is an emerging and revolutionary diagnostic tool in critical care and internal medicine. With its non-invasive nature, real-time imaging capability, and absence of ionizing radiation, LUS offers several advantages over traditional imaging modalities such as chest radiography and Computed Tomography (CT) in the assessment of lung conditions. As healthcare practices evolve, especially in critical care environments, the need for effective and accessible diagnostic tools has never been more paramount. LUS has risen to meet these needs, demonstrating utility across a wide range of clinical scenarios from Acute Respiratory Distress Syndrome (ARDS) to heart failure, pneumonia, and trauma.

Although traditionally, the primary imaging tool for lung evaluation was chest X-ray or CT scans, these technologies have inherent limitations, such as exposure to radiation and difficulty in providing real-time data, particularly in unstable patients. In contrast, lung ultrasound, despite being initially underutilized, has proven to be an effective tool in diagnosing and managing lung pathologies, especially when integrated with clinical assessment. This article provides an evidence-based review of the role of lung ultrasound in critical care and internal medicine, exploring its applications, benefits, challenges, and future directions [1].

Description

Lung ultrasound uses high-frequency sound waves to generate images of the lung and surrounding structures, allowing the operator to assess the condition of the lungs in real-time. Unlike other imaging techniques that rely on radiation, LUS utilizes sound waves, which are harmless, making it especially useful in settings where repeat imaging is necessary, such as the Intensive Care Unit (ICU). In addition, LUS can be performed at the patient's bedside, making it convenient for patients in critical condition who may be too unstable to be transported to imaging departments. Ultrasound technology works on the principle of emitting sound waves that bounce off tissues and return to the ultrasound probe. These waves produce echoes that are converted into images. Since air in the lungs does not transmit sound well, healthy lungs appear relatively free of any significant ultrasound reflections. However, abnormalities in lung tissues such as consolidation, edema, or pleural effusion create different patterns on the ultrasound that can be interpreted to diagnose pathologies. Pneumonia, particularly in critically ill patients, is a significant cause of morbidity and mortality. While chest X-ray is commonly used to detect pneumonia, it is not always reliable in the ICU setting, particularly in patients with altered physiology, such as mechanical ventilation. Lung ultrasound offers an accurate alternative for the diagnosis of pneumonia. Studies have shown that LUS has a sensitivity of up to 90% and specificity greater than 90% in diagnosing pneumonia. The appearance of lung consolidation on ultrasound, characterized by a hypoechoic area with irregular borders and air bronchograms, is a typical finding in bacterial pneumonia [2].

Pulmonary edema, particularly cardiogenic pulmonary edema, is a life-threatening condition often seen in patients with heart failure or after major surgery. Detecting pulmonary edema in a timely manner is crucial for appropriate management. Lung ultrasound plays a key role in identifying the presence of B-lines (vertical hyperechoic lines originating from the pleural line), which are indicative of pulmonary interstitial edema. The number and distribution of these B-lines provide important information about the severity of edema and guide the treatment strategy. In some cases, LUS can detect pulmonary edema before it is visible on chest X-ray, enabling earlier intervention. Acute Respiratory Distress Syndrome (ARDS) is a complex syndrome resulting from a variety of causes such as pneumonia, aspiration, or trauma. Early identification of ARDS is crucial for improving patient outcomes. Lung ultrasound has shown promise in assessing ARDS, particularly in distinguishing it from other causes of respiratory distress, such as cardiogenic pulmonary edema. The ultrasound findings in ARDS typically include widespread B-lines, consolidation, and a lack of a well-defined pleural line. This can be used to assess the progression or resolution of ARDS, providing clinicians with valuable real-time information to guide therapeutic decisions [3].

Trauma, especially rib fractures, is another common scenario where lung ultrasound can be helpful. Rib fractures can lead to complications such as pneumothorax or hemothorax. While chest X-rays may fail to detect small pneumothoraces, LUS can identify the absence of normal lung sliding (sign of pneumothorax) and other pathologies. The ability to perform LUS at the bedside in trauma situations makes it an invaluable tool for rapidly identifying life-threatening complications in unstable patients. Unlike chest X-ray and CT scans, LUS does not use ionizing radiation, making it safe for repeated use, even in pregnant patients or those requiring frequent monitoring. Ultrasound machines are portable and can be used at the bedside, making it ideal for critically ill patients who may not be able to leave the ICU or emergency room for imaging. LUS provides immediate results, allowing clinicians to make quick decisions in urgent and critical situations. LUS is less expensive than CT scans and does not require extensive infrastructure, making it more affordable for hospitals and healthcare systems [4,5].

Conclusion

Lung ultrasound is rapidly gaining recognition as a valuable diagnostic tool in both critical care and internal medicine. It offers numerous advantages over traditional imaging modalities, including safety, portability, real-time imaging, and cost-effectiveness. With applications ranging from the diagnosis of pneumonia and pleural effusion to the assessment of ARDS and trauma-related conditions, LUS has proven to be a versatile and essential tool in modern medical practice. However, like any diagnostic modality, lung ultrasound has its limitations, particularly with regard to operator dependence and limited visualization of deeper structures. Training and experience are key to maximizing its utility and minimizing the risk of misinterpretation. With continued research and increased adoption, lung ultrasound is poised to play a central role in improving patient outcomes in critical care and internal medicine settings. Lung ultrasound represents an exciting and evidence-

***Address for Correspondence:** Lednev Montorio, Department of Rheumatology and Internal Diseases, Medical University of Lodz, 90-549 Lodz, Poland, E-mail: lednevmontorio.ontori@iro.pl*

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based advancement in the management of critically ill patients. As technology improves and clinician expertise expands, its role in both acute and chronic care settings will continue to grow, shaping the future of respiratory medicine.

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Conflict of Interest

None.

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