# Enhanced Diagnosis of Severe Community-acquired Pneumonia by Lung Ultrasound

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## Abstract

Lung ultrasound (LUS) has emerged as a crucial tool in the diagnosis and monitoring of acute respiratory failure, particularly in critically ill patients. In this case, a man in his late 50s presented to the emergency department with respiratory distress and rapidly deteriorated, requiring invasive ventilation and intensive care unit admission for septic shock and multiorgan dysfunction. LUS revealed extensive consolidation with linear–arborescent dynamic air bronchogram, specific for community-acquired and ventilator-associated pneumonia, with a global LUS score of 22, indicating significant severity. LUS demonstrated greater sensitivity and specificity compared to chest radiography, allowing for a more reliable and timely diagnosis. The use of LUS was especially valuable given the patient's hemodynamic instability, which made computed tomography unfeasible. As a portable, radiation-free imaging modality, LUS offers significant advantages over traditional methods, particularly in emergency and critical care settings, where rapid bedside assessments are essential for guiding treatment and ensuring continuous patient monitoring.

**Keywords:** Dynamic air bronchogram, lung ultrasound, pneumonia

A man in his late 50s with a history of human immunodeficiency virus infection and alcohol-related liver cirrhosis presented to the emergency department with fever, dyspnea, and productive cough. On physical examination, there were evident signs of respiratory distress, with oxygen saturation of 88% on 50% supplemental oxygen by Venturi mask. Blood gas analysis revealed hypoxemia ($PaO_2/FiO_2$ of 117) and severe metabolic acidosis with hyperlactatemia (20 mmol/L). Laboratory tests showed elevated levels of inflammatory markers, mild thrombocytopenia, and hyperbilirubinemia (9.3 mg/dL). Nasopharyngeal swab for influenza A virus and pneumococcal urinary antigen test were positive. Chest radiography identified an opacity in the left lung field, sparing the apex and costophrenic sulcus. Blood cultures were collected, and the patient was started on antibiotic therapy.

The patient rapidly developed ventilatory failure, which required orotracheal intubation and invasive mechanical ventilation despite a trial of noninvasive ventilation. Subsequent intensive care unit (ICU) admission was required because of septic shock with multiorgan dysfunction. Computed tomography (CT) scan was not feasible due to hemodynamic instability and worsening oxygenation; therefore, lung ultrasound (LUS) was performed. There was consolidation with linear–arborescent dynamic air bronchogram in the entire left lung, including the apex and costophrenic sulcus, which is specific for community-acquired and ventilator-associated pneumonia [Videos 1 and 2]. In the right lung, it was already possible to identify subpleural consolidations, particularly in the lateral and posterior areas [Video 3].

Over the next 24 h, the patient's respiratory failure worsened, necessitating neuromuscular blockade and prone positioning. Hemodynamic instability also progressed despite vasopressor support with norepinephrine and vasopressin. In addition, the patient developed oliguric acute kidney injury and

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refractory metabolic acidosis, leading to the initiation of renal replacement therapy. Despite all therapeutic interventions, the patient ultimately died on the 2nd day of hospitalization.

Given its availability in various resource settings, LUS has recently become increasingly recognized as a prominent imaging technique for the diagnosis and monitoring of acute respiratory failure. Although CT is the gold standard for thoracic imaging, it is associated with radiation exposure and increased cost, lower accessibility, and requirement of transportation of patients to the radiology department, which could pose risks for the critically ill patients.[1,2] In contrast, portable chest radiography has limited resolution and is poorly informative in cases with almost completely deaerated lungs.[3]

In the emergency department, LUS can be utilized early in the diagnostic process to rapidly assess lung aeration and identify conditions such as pneumonia, pleural effusion, or pneumothorax. It can reveal lung infiltrates and signs of pneumonia more reliably and quickly than chest radiography, as consolidations have 93% sensitivity and 98% specificity for a diagnosis of community-acquired pneumonia.[1,4] In fact, an ultrasound-guided approach for patients with respiratory failure in the emergency department resulted in more accurate early diagnoses, timely treatments, and improved utilization of advanced imaging techniques such as CT scan.[5]

In patients admitted to ICU, LUS plays a crucial role in daily monitoring of lung aeration, allowing clinicians to assess disease progression, response to therapy, and early detection of complications like acute respiratory distress syndrome (ARDS) or ventilator-associated pneumonia.[3,4] This integration into daily ICU rounds reduces the need for transporting critically ill patients for CT scans and minimizes radiation exposure, while also offering real-time, bedside information that aids in treatment adjustments.

Moreover, LUS can be incorporated into hospital-wide protocols for managing respiratory conditions, particularly in settings where advanced imaging modalities are not readily available. Given its portability, LUS can be implemented in both resource-rich and resource-limited settings, making it a versatile tool in various clinical environments. In addition, training programs can be incorporated into emergency and critical care curricula to ensure that clinicians are proficient in performing and interpreting LUS.

The LUS score allows clinicians to evaluate the severity of lung disease at the time of hospital admission and monitor changes in lung aeration on a daily basis. It distinguishes four progressive steps of loss of aeration according to the artifacts visualized: score 0 - normal aeration (A-lines or no more than two B-lines); score 1 - moderate loss of aeration (three or more well-spaced B-lines, coalescent B-lines, and/or subpleural consolidations occupying ≤50% of the pleural line); score 2 - severe loss of aeration (well-spaced B-lines, coalescent B-lines, and/or subpleural consolidations occupying >50% of the pleural line); and score 3 - complete loss of aeration (tissue-like pattern). The score is calculated as the sum of six regional scores per hemithorax (anterior, lateral, and posterior fields are identified by sternum, anterior, and posterior axillary lines; each field is divided into superior and inferior regions) and ranges from 0 (all regions are well aerated) to 36 (all regions are consolidated).[3,4,6] In a previous study, the global LUS score showed a statistically significant association with lung tissue density and a significant inverse relationship with gas/volume ratio as assessed by CT.[7] In this case, the global LUS score was 22. Therefore, LUS enabled a more precise diagnosis and revealed greater severity compared with chest radiography.

Most studies exploring the relationship between LUS scores and clinical outcomes focus on COVID-19-related respiratory failure. These studies have shown that higher LUS scores (>12) are associated with worse clinical outcomes, including mortality and the development of ARDS.[8] Particularly in COVID-19 patients, a cutoff point of 18 has been identified, above which the need for mechanical ventilation increases and survival rates significantly decline.[9] A recent study assessing the diagnostic value of combining LUS with serum inflammatory markers for evaluating the severity and prognosis of pneumonia found a positive association between the LUS score and disease severity.[10] Furthermore, this combination was closely linked to patient prognosis, helping guide early clinical interventions.

In conclusion, LUS has been proven to be crucial for improving patient safety and helping clinicians make bedside diagnoses while also ensuring continued patient monitoring.[2]

## Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent form. In this case, the authors have obtained informed consent from the patient's next of kin, as the patient is deceased. The patient's next of kin understand that his name and initials will not be published and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.

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## Conflicts of interest

There are no conflicts of interest.

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