



## Case report

### Assessment of the applicability of transthoracic lung ultrasound for diagnosing purulent lobar pneumonia: A case study

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#### ABSTRACT

**Introduction:** Purulent lobar pneumonia is an inflammation of pulmonary tissue that may progress to parenchymal necrosis and abscess formation. The authors present a case of purulent lobar pneumonia diagnosed using transthoracic lung ultrasound (TLU). Abscess-type lesions had not been visualized in previous computed tomography (CT) scans.

**Aim:** To analyze the potential of TLU as a diagnostic tool for purulent lobar pneumonia.

**Case study:** A 55-year-old patient with a several-week history of cough, abdominal pain, and diarrhea was admitted to the intensive care unit due to rapidly progressing cardiopulmonary failure. CT revealed merging parenchymal/interstitial densities within the right lung. Broad-spectrum antibiotics were initiated. TLU revealed the presence of lesions characteristic of pneumonia with the development of abscesses and acute respiratory distress syndrome. Despite treatment initiation, the patient's condition progressively worsened. On the 3rd day of hospitalization, the patient passed away. At autopsy, purulent lobar pneumonia was identified as the direct cause of death.

**Results and discussion:** Despite broad and well-documented knowledge regarding its applicability, ultrasound has not been widely used as a diagnostic tool.

**Conclusions:** TLU is a safe, repeatable, and inexpensive diagnostic tool. The use of ultrasound in diagnosing pneumonia is well documented, and based on specific diagnostic criteria. As a diagnostic tool for pneumonia, dynamic air bronchogram had a high specificity and positive predictive value. The high sensitivity and specificity of TLU, as pertains to detecting necrosis or abscesses in the course of pneumonia, is comparable with CT. TLU facilitated visualization of small-diameter abscesses.

## 1. INTRODUCTION

The natural progression of pneumonia involves the accumulation of exudate and cellular elements within the lumen of pulmonary alveoli.<sup>1–4</sup> The affected tissue becomes airless and, thus, exhibits a shaded area in radiograms (i.e., X-rays). In ultrasonography, these types of pulmonary changes are referred to as alveolar consolidations. The diagnosis of pneumonia is based on clinical examination and radiography. According to histological and radiological criteria, lobar pneumonia is defined as inflammation of pulmonary tissue extending over a single lobe or segment of a lung. Abscesses may develop when the course of the disease involves parenchymal necrosis.<sup>2,5–7</sup>

## 2. AIM

We present a case involving a patient with purulent lobar pneumonia diagnosed using transthoracic lung ultrasound (TLU). Abscess-type lesions had not been visualized in previous computed tomography (CT) scans. Furthermore, we analyze the potential of TLU as a diagnostic tool for purulent lobar pneumonia.

## 3. CASE STUDY

A 55-year-old patient with several weeks' history of cough, abdominal pain and diarrhea, was admitted to the intensive care unit of Department of Anaesthesiology and Intensive Care, Regional Specialist Hospital in Olsztyn, Poland due to rapidly progressing cardiopulmonary failure. On admission, the patient was in critical condition, unconscious, with trace limb withdrawal reflex in response to pain. The pupils were narrow, evenly sized, and reactive. The patient exhibited respiratory insufficiency and, accordingly, was intubated requiring respiratory support in SIMV mode, with a fraction of inspired oxygen (FiO<sub>2</sub>) value of 1.0. Thoracic mobility was unremarkable, and vesicular murmur bilaterally present. The patient presented with large quantities of secretion within the airways and deep hypotension. Invasively measured blood pressure (60/30 mmHg) was stabilized using dopamine infusion. The heart presented with sinus rhythm at a rate of 140 bpm. Capillary refill time was prolonged. The abdomen was soft, free of pathological resistance, with audible peristalsis sounds; body temperature was 38.5°C. CT scan performed on admission revealed massive, merging areas of parenchymal/interstitial densities within the right lung as well as a high quantity of fluid in the right pleural cavity.

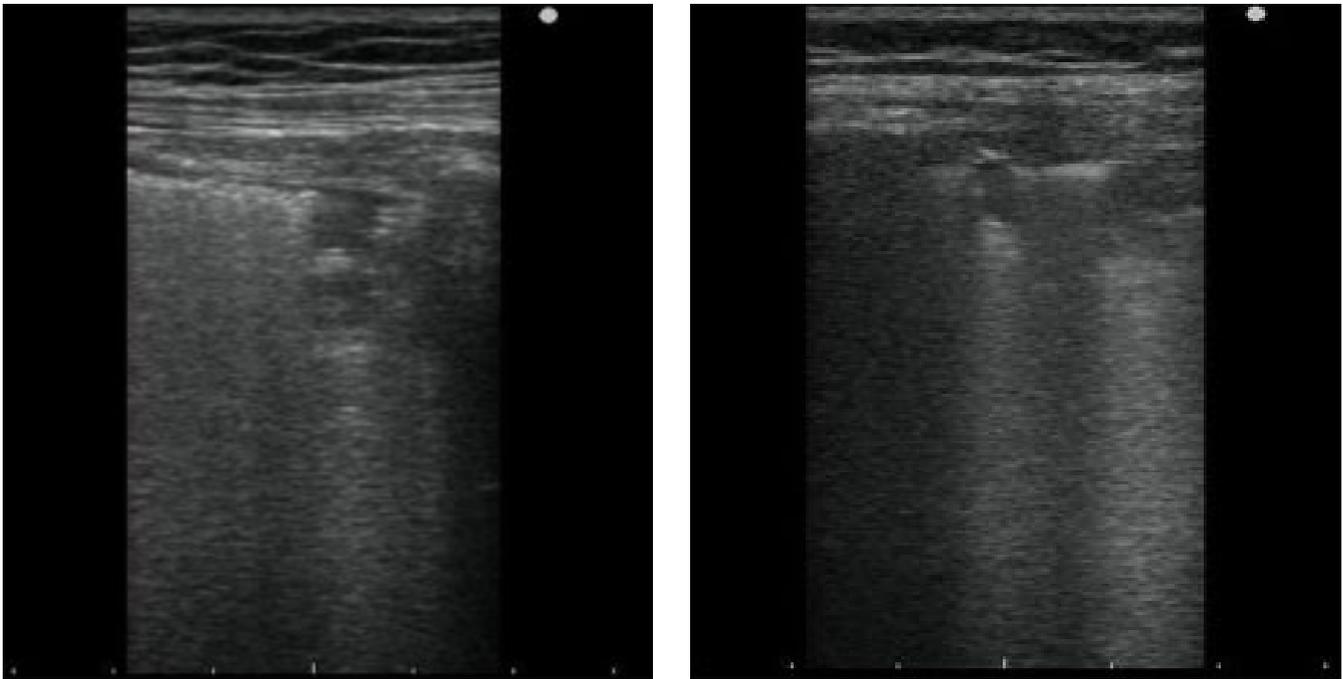
After admission, the patient received respiratory ventilation, fluid therapy, and pressor amines (noradrenaline, dopamine, dobutamine). Samples were collected for laboratory analyses and cultures, including a bronchoalveolar lavage (BAL) sample. Empirical antibiotic therapy (vancomycin, clindamycin, cefepime) was initiated, in addition to a pharmacological anticoagulation prevention and accurate blood

glucose monitoring protocol. A central cannula was placed in the right subclavian vein, and arterial cannula was placed in the right femoral artery. The patient was connected to continuous monitoring of cardiac output, which revealed septic shock. A drain was placed in the right pleural cavity. Laboratory investigations revealed hypoxemia with metabolic acidosis, leukopenia, thrombocytopenia, hypoalbuminemia, as well as elevated inflammatory and renal parameters. Despite this treatment, the overall condition of the patient continued to deteriorate. A dialysis line was placed in the left femoral vein and continuous renal replacement therapy (HVCVVHD) was initiated. Antibiotic therapy was modified to include meropenem, linezolid, levofloxacin, metronidazole, and oseltamivir. The range of diagnostic examinations was expanded in search for other causes of pneumonia. Viral etiology was eliminated in the test results. TLU was performed and revealed numerous, non-uniformly distributed line-B artifacts above the anterior and lateral surface of the lung, with healthy areas visible between these artifacts. Numerous subpleural consolidations of various sizes with irregular outlines and dynamic air bronchograms were observed (the largest, 19 × 20 mm, was located at the lateral surface of the right lung). Pleural line fragmentation was observed above the consolidations. Fluid was detected in large quantities at the base of the right lung, as well as in a small quantity in the immediate surroundings of these consolidations. In addition, the lateral surface of the right lung presented with two oval, hypoechoic lesions (8 × 5 mm, and 7 × 6 mm), surrounded by a moderately hypoechoic bursa, with no flows being detected in color Doppler mode (Figure). Conclusions drawn from the examination results were suggestive of necrotic pneumonia and acute respiratory distress syndrome. *Streptococcus pneumoniae* and *Staphylococcus aureus* were cultured from BAL samples, with the remaining cultures remaining pathogen-free.

Due to the lack of improvement and despite initiated treatment, including optimal respiratory support, a decision was made to include extracorporeal membrane oxygenation. Initially, a slight improvement in oxygenation – allowing for a reduction in FiO<sub>2</sub> value from 1.0 to 0.8 in the respirator settings – was observed, but was insufficient to control acidosis. Continued observation revealed deepening shock with massive peripheral perfusion disorders (livid spots on the entire body, predominantly on the lower half), and hypothermia non-responding to external heating as well as during HVCV-VHD. Cardiac arrest of asystole mechanism occurred on the 3rd day of hospitalization. Resuscitation efforts were implemented; however, heart action could not be restored and the patient was declared deceased. Purulent lobar pneumonia was identified as the direct cause of death at autopsy examination.

## 4. RESULTS AND DISCUSSION

Chest X-ray is the primary tool for the diagnosis of pneumonia. Despite the broad and well-documented knowledge regarding its applicability, ultrasound is not widely used as a diagnostic tool. To diagnose pneumonia on the basis of an



**Figure. Evolution of abscess in transthoracic lung ultrasound.**

ultrasound scan, the following criteria should be taken into account:<sup>8</sup>

- (1) Parenchymal criteria: subpleural consolidation of pulmonary parenchyma, air bronchogram, fluid bronchogram, superficial fluid alveologram;
- (2) Pleural criteria: fluid within the pleural cavity, either localized or at the lung base; and
- (3) Vascular criteria.

Consolidations are a common trait in pneumonia. *Pneumococcal pneumonias* present with typical images of consolidations. Of note are massive, hypoechoic changes in the echostructure resembling those of the liver. The dimensions of these consolidations are not altered by breathing. This is referred to as the ‘tissue-like sign.’ In addition, a typical irregularity of the border between the lesion and normally aerated pulmonary tissue, referred to as the ‘shred sign.’ If both signs are present, the sensitivity and specificity of ultrasound scans in the diagnosis of alveolar consolidations – compared with gold standard CT – are 90% and 98%, respectively.<sup>8</sup> However, one must keep in mind that only consolidations that are in contact with the pleura are visualized in the ultrasound scans. This, however, is not a serious limitation because 98.5% of lesions are located subpleurally.<sup>8</sup>

Dynamic air bronchogram reveals characteristic features of consolidations in the course of pneumonia.<sup>3,7,9,10</sup> The movement of bronchograms is due to the relocation of air within the alveoli. In the M mode, they present as sinusoidal lines on inhalation. As a diagnostic tool in pneumonia, dynamic air bronchogram has a specificity of 94% and positive predictive value of 97%.<sup>3,7,10</sup> The presence of fluid within the pleural cavity is a sign of the inflammation affecting the pleura as well as pulmonary parenchyma. Initially, fluid accumulates in the surroundings of the affected area, but may be finally relocated to the lung base. The incidence

of local and basal presence of fluid is estimated to be 9% and 60%, respectively. The natural progression of pneumonia may also include the involvement of pleura presenting with hypoechoic and fragmentation in the vicinity of consolidations.<sup>11,12</sup>

Vascular flows within the consolidations may be assessed using color-coded Doppler scans. This option may be helpful in differentiating lesions of inflammatory origin from those developing in the course of pulmonary embolism. However, one must keep in mind that movements of the ultrasound probe or the patient’s chest may produce flash artifacts. Therefore, according to some authors, the vascular criterion is not a reliable sign of pneumonia.<sup>13</sup> Abscesses may develop when the course of the disease involves parenchymal necrosis. Ultrasonographic visualization of abscesses is possible only when they are located within the consolidations. Usually, abscesses present as hypoechoic (relative to the surrounding consolidation), round- or oval-shaped lesions with smooth, echogenic borders.<sup>12</sup> They may be accompanied by slight pleural effusion. If the scan of the intercostal region is acquired with the patient in a sitting position, air/fluid levels may be visible within the abscess.<sup>14,15</sup> In such case, air presents as hyperechoic with posterior acoustic shadowing. If the fluid is under atmospheric pressure, a ‘free swirl’ sign may be observed. The capacity of TLU to detect necrosis or abscesses in the course of pneumonia is comparable with CT. In the case described, abscess-type lesions had not been visualized in previous CT scans. TLU was the only diagnostic imaging examination capable of revealing the presence of abscess-type lesions. In addition, microabscesses (i.e., lesions less than 20 mm in diameter) are more frequently visualized in TLU scans compared with lung radiograms. The appearance of these lesions is similar to that of small cysts.<sup>2,5,6</sup>

## 5. CONCLUSIONS

Transthoracic lung ultrasound appeared to be a safe, repeatable, and inexpensive diagnostic tool, and the use of ultrasound for the diagnosis of pneumonia is based on specific diagnostic criteria and has been well documented. As a diagnostic tool for pneumonia, dynamic air bronchogram has a high specificity and positive predictive value. The high sensitivity and specificity of TLU, as it pertains to detecting necrosis or abscesses in the course of pneumonia, is comparable with CT, and may facilitate the visualization of small-diameter abscesses.

### Conflict of interest

No conflict of interest.

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### Ethics

Written informed consent was obtained from the patients and their parents for publication of this research report. A copy of the written consent is available for review by the Editor of this journal.

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