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Lung Ultrasound to Diagnose Necrotizing Pneumonia in the Pediatric Patient

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Case Study

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ABSTRACT

Necrotizing pneumonia, a severe complication of community-acquired pneumonia, poses a significant risk of potentially fatal outcomes if not promptly identified and treated. The current standard of care in the emergency room involves an initial plain radiograph of the chest followed by a computed tomography scan, considered the gold standard for diagnosis. In this case report, we present the unique scenario of a 3-year-old child initially diagnosed with pneumonia and subsequently revealed to have necrotizing pneumonia through the utilization of lung ultrasound. This case highlights the potential efficacy of employing lung ultrasound as a primary diagnostic tool for identifying necrotizing pneumonia in the pediatric population, challenging the conventional diagnostic pathway.

Keywords: Necrotizing pneumonia; bronchial breath sounds; c-reactive protein; chest radiograph.

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1. INTRODUCTION

Necrotizing pneumonia (NP) is a rare but serious complication arising from a common condition in the pediatric population—community-acquired pneumonia (CAP). Necrosis of the lung parenchyma is a vascular process triggered by infection, resulting in vessel thrombosis and cavity formation. The most common bacterial organisms causing this process are *Streptococcus pneumoniae* and *Staphylococcus aureus.* While viral illnesses are rarely a sole cause of NP, a preceding viral illness is a significant risk factor [1].

Most NP cases occur in immunocompetent children, with a median patient age of 4 years. Clinical manifestations typically encompass fever, tachypnea, cough, abdominal pain, and chest pain. Physical examination often reveals dullness to percussion, decreased breath sounds, crackles, and bronchial breath sounds. Laboratory findings associated with NP include leukocytosis, anemia, hypoalbuminemia, and elevated acute-phase reactants such as C-reactive protein (CRP) and platelets [2]. Positive blood culture results are less frequent due to prior antibiotic use in many patients before hospitalization [1].

The diagnosis of NP relies on imaging studies, with one-third of cases initially identified through chest radiographs (CXR) revealing cavitary lesions with air-fluid levels. However, distinguishing consolidation from fluid-filled lesions on CXR in the early disease stages can be challenging. Contrast-enhanced chest computed tomography (CT) scans are considered the diagnostic gold standard for NP [1]. Lung ultrasonography (LUS) has emerged as an alternative for evaluating and identifying consolidations. In healthy lungs, the pleural line appears as smooth hyperechoic lines beneath the ribs, with ribs casting shadows as the ultrasound beam cannot penetrate bone. Normal air filled lung parenchyma gives rise to an artifact pattern called A-lines which run parallel to the pleural line. B-lines are hyperechoic lines arising from and running perpendicular to the pleura or consolidation. An increase in number and density of B-lines, as well as a lack of A-lines, correlates with thickened interlobular septae and increased interstitial fluid or infiltration representing interstitial disease. Air bronchograms are seen as hyperechoic specs within the area of consolidation. Large consolidations can exhibit a liver-like appearance termed hepatization [3]. Hypoechoic lesions (HL) within the consolidated lung are an ultrasonographic finding of NP. Impaired perfusion and HLs are useful for diagnosis and prediction of severity of NP [4]. Lung ultrasound is being utilized increasingly more to aid the diagnosis of NP.

2. CASE PRESENTATION

A 3-year-old male with speech delay presented with fever for five days. The patient had one episode of emesis. He was overall well appearing with his normal activity and oral intake. He was brought to the emergency department (ED) due to his persistent fevers. In the ED, the patient was found to be febrile with a temperature of 102 degrees Fahrenheit and Acetaminophen was given. On physical exam, the patient's lungs were clear to auscultation bilaterally. Bloodwork revealed a white blood cell count (WBC) of $24.60x10^3$ mcL, an erythrocyte sedimentation rate (ESR) of 93 and a CRP of 129. Blood culture (BCx) was collected and afterwards, a dose of Ceftriaxone dose was given in the ED. He was discharged home with strict instructions to return to the ED the following day for reevaluation.

The next day, the patient returned to the ED as requested. He continued to have fevers but denied any other symptoms including cough. Repeat labs were notable for a WBC of $17.86x10^3$ mcL, ESR of 95, and CRP of 139. CXR done which showed findings consistent with viral illness as well as a left upper lung consolidation as well as mild cardiomegaly (Fig. 1). Electrocardiogram and echocardiogram were unremarkable. A COVID-19 polymerase chain reaction test was negative. The patient was admitted to the pediatric floor where Ceftriaxone was continued. Initial BCx from the patient's first ED visit showed a Staphylococcal species. ESR was repeated and remained elevated at 104. A second BCx which was collected at the patient's second ED visit was found to be no growth for two days. The patient was discharged home on a seven day course of Cefdinir.

Four days after discharge, the patient returned to the ED with worsening symptoms. His cough had worsened and he was now experiencing post-tussive emesis and decreased activity level. The patient's fevers persisted at home. He continued Cefdinir as prescribed with little improvement. On physical exam lungs were found to have good air entry and were clear to auscultation bilaterally.

No wheezing, crackles, or rhonchi were appreciated. Bloodwork showed the leukocytosis increased to a WBC of $34x10^3$ mcL, CRP 65.7, procalcitonin of 0.16, ESR 85. Due to the persistent of the patient's symptoms a point of care LUS was done. Bedside ultrasound of lungs showed a normal right lung (Fig. 2a). The left upper lung zone showed hypo-echogenic air inclusions signifying a necrotic abscess (Fig. 2b) consistent with a diagnosis of NP. Given the findings of the LUS, a CXR was then done which showed left upper lobe consolidation with lucency (Fig. 3). A follow up CT chest with contrast confirmed the diagnosis of a necrotizing cavitary lesion which was initially found on LUS (Fig. 4). The patient was given a dose of Ampicillin and Sulbactam and Vancomycin. A third blood culture was collected. COVID-19 polymerase chain reaction test was repeated and remained negative.

The patient was admitted to the pediatric floor for further management. The antibiotics were switched to Piperacillin and Tazobactam and Clindamycin following recommendations from infectious disease (ID). The third BCx returned no growth. Cough and fever resolved. The patient was back to his baseline. He completed a fourteen day intravenous antibiotic course of Clindamycin and Piperacillin and Tazobactam during admission. Near the end of the patient's hospitalization a repeat CBC showed resolution of leukocytosis with WBC of $9.87x10^3$ mcL. A repeat CXR done prior to discharge showed mild residual hazy density in the medial left upper lobe with no central lucency (Fig. 5).

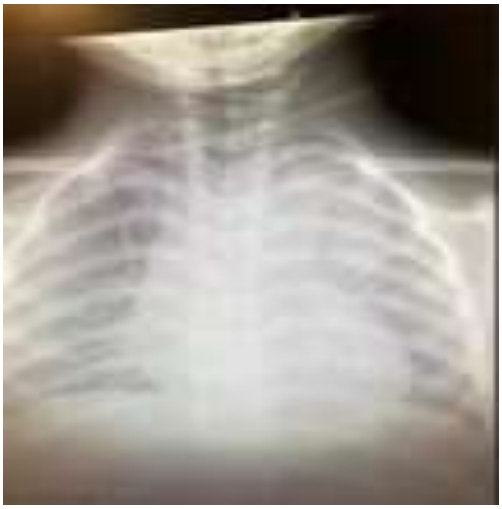

Fig. 1. Plain radiograph of the patient's chest during initial admission revealing left upper lobe consolidation

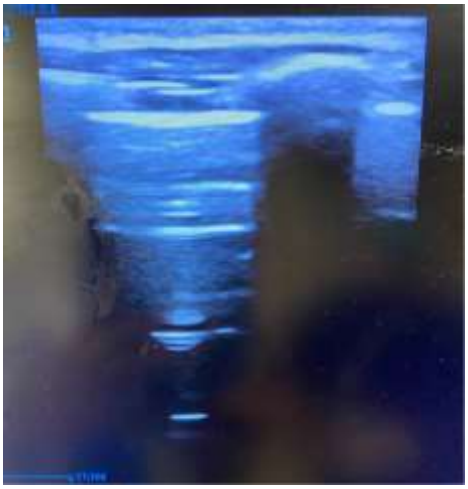

Fig. 2a. Ultrasound of the patient's right lung in the emergency room showing normal lung echo pattern with a smooth pleural line and A-lines

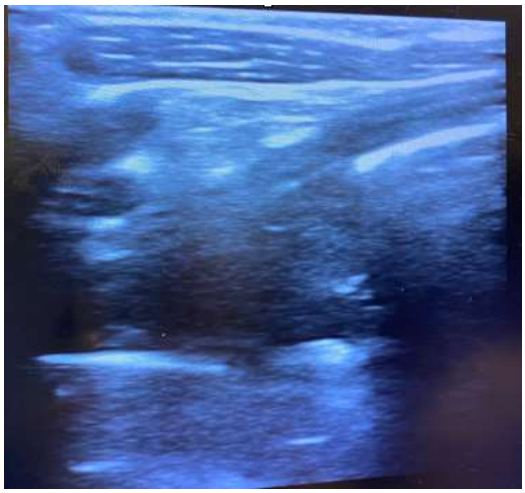

Fig. 2b. Ultrasound of the patient's left upper lung zone revealing interstitial disease with necrotic change

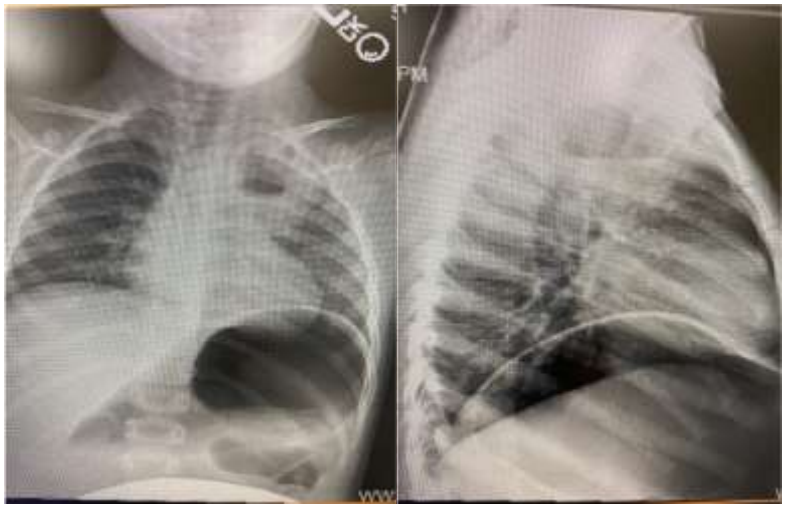

Fig. 3. Plain radiograph of the patient's chest in AP and lateral views showing left upper lobe consolidation with lucency

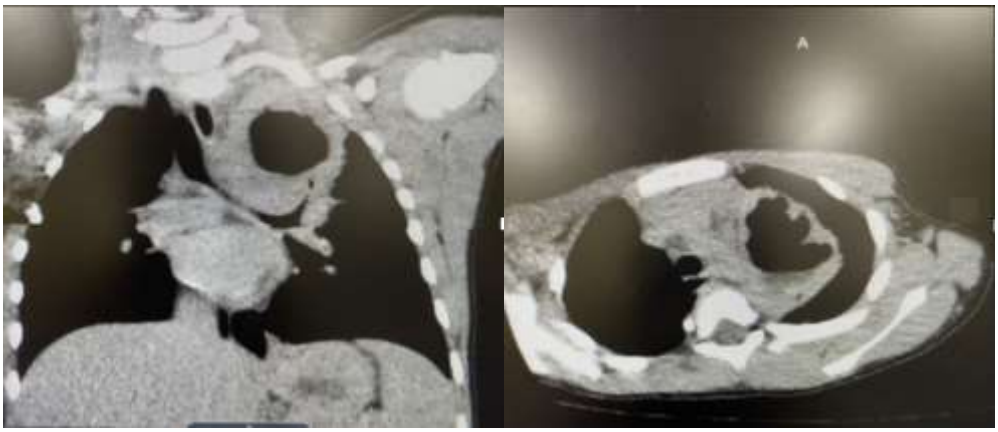

Fig. 4. The patient's CT chest with contrast showing large gas and fluid containing collection in the left upper lobe with irregular wall confirming what was seen in ultrasound and CXR

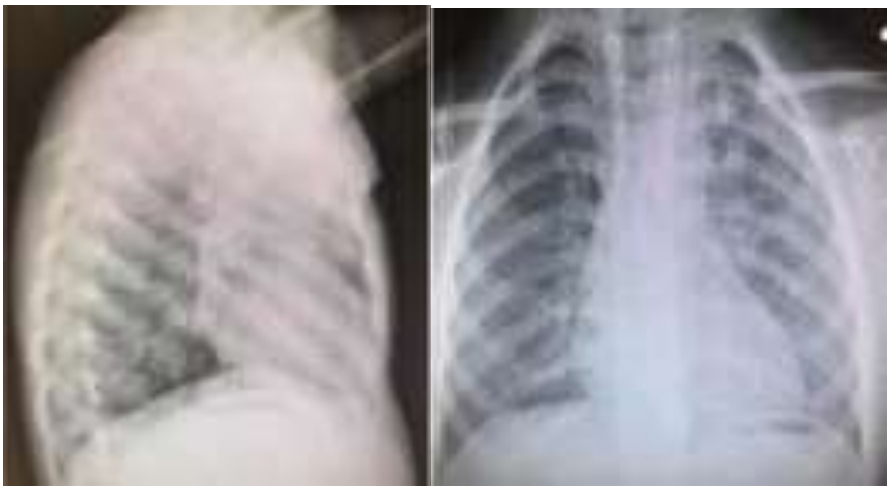

Fig. 5. Pain radiograph of the patient's chest done prior to discharge showing improved mild residual density in the left upper lobe with no central lucency compared with Fig. 3.

The patient was discharged home on fourteen additional days of oral Amoxicillin and Clavulanic acid. Outpatient ID follow up confirmed resolution of his symptoms.

3. DISCUSSION

Point of Care Ultrasound (POCUS) of the lung has demonstrated sensitivity equal to or greater than that of a chest X-ray (CXR) for evaluating and diagnosing pneumonia in the emergency room [5]. While CXR is relatively fast and inexpensive, it has limitations, particularly in exposing patients to ionized radiation. Furthermore, a negative CXR does not definitively rule out interstitial disease and lacks sensitivity in detecting smaller lung consolidations [3]. In contrast, lung ultrasound (LUS) emerges as a safe imaging modality, especially when necrotizing pneumonia is suspected [4]. Its immediate availability and accessibility offer rapid diagnostic capabilities, yet its underutilization persists, potentially due to time constraints in busy clinical settings, as a LUS may take up to 10 minutes [3]. Nevertheless, studies have demonstrated that POCUS lung studies are cost-effective and contribute to decreased length of stay for emergency department (ED) patients compared to CXR use [6].

Despite ultrasound training being well-established in emergency medicine, it remains less emphasized in primary care specialties such as pediatric residency, where practitioners may have limited training in POCUS prior to graduation [7]. POCUS lung evaluation, however, is a teachable skill, with studies indicating that even short training sessions, as brief as an hour, enable novice sonographers to reliably diagnose abnormal lung findings [8]. Therefore, increased emphasis on training practitioners in LUS usage is warranted, as accurate technique renders LUS sufficient in diagnosing necrotic lung lesions [4].

CT is commonly used in cases of suspected necrotizing pneumonia, aiding in identifying hypoperfusion [9]. However, CT poses challenges, including unnecessary radiation exposure, high costs, and, at times, the need for sedation [4]. Additionally, the contrast used in CT carries a risk of acute kidney injury, especially in patients with reduced kidney function [10]. LUS, when combined with Doppler studies, can detect similar changes early in pediatric patients, providing a non-invasive alternative [4]. There is controversy surrounding the initial use of CT in all children with lung cavities as there is a potential need for repetitive imaging due to treatment failure, resulting in increased radiation exposure [9].

4. CONCLUSION

Necrotizing pneumonia stands as a critical complication of community-acquired pneumonia in children, warranting consideration as a differential diagnosis in cases where patients show no improvement on antibiotics [2]. Recognizing necrotic changes on imaging is crucial, and LUS emerges as a valuable tool in the initial diagnosis of necrotizing pneumonia, potentially surpassing the efficacy of CXR [4]. There is a conceivable role for using LUS instead

of CXR or even CT in diagnosing necrotizing pneumonia in the emergency department. However, further research is imperative to validate the substitution's validity and fully comprehend the nuances of its application in diverse clinical scenarios.

CONSENT

As per international standards, parental written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

As per international standards or university standards written ethical approval has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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