Case study

Lung Ultrasound to Diagnose Necrotizing Pneumonia in the Pediatric Patient

Abstract:
Necrotizing pneumonia is a severe complication of community-acquired pneumonia. If not identified and adequately treated it may lead to potentially fatal outcomes. Currently the standard of care in the emergency room is initially a plain radiograph of the chest followed by a computed tomography of chest which is the gold standard for diagnosis. We present a case of a 3-year-old child who presented with fever and was initially diagnosed with pneumonia. The patient was then found to have necrotizing pneumonia which was initially discovered on lung ultrasound. This case report explores the possibility of usinglung ultrasound as a first line in the diagnosis of necrotizing pneumonia in the pediatric population.

Introduction

Necrotizing pneumonia (NP) is a rare but serious complication of a common entity in the pediatric population- community acquired pneumonia (CAP). Necrosis of the lung parenchyma is a vascular process triggered by infection leading to thrombosis of vessels 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 children with NP are immunocompetent. Median age of patients is 4 years of age. Clinical features most commonly seen are fever, tachypnea, cough, abdominal pain and chest pain. On physical exam patients have dullness to percussion, decreased breath sounds, crackles and bronchial breath sounds. NP is associated with leukocytosis, anemia, hypoalbuminemia, and elevated acute phase reactants such as c-reactive protein (CRP) and Platelets (2). Positive blood culture results in less than half of patients as many patients have received antibiotics prior to hospitalization (1).

NP diagnosis is confirmed using imaging studies. One-third of diagnoses is made upon chest radiograph (CXR) which shows cavitary lesions with air fluid levels. It is difficult to differentiate consolidation from fluid filled lesions on CXR early in the disease process. These lesions become more apparent later on. Contrast-enhanced chest Computed tomography (CT) scans are the standard for diagnosis of NP (1). Lung ultrasonography (LUS) can also be used to evaluate and identify consolidations. In healthy lungs, the pleural line is visualized as smooth hyperechoic lines deep to the ribs. Ribs are seen as a shadow 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 have a liver-like appearance called 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.

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'slungs 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 CRPof 129. Blood culture (BCx)was collected and afterwards, a dose of Ceftriaxone dose was given in the ED. He wasdischarged 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 fora 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 (Figure 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 BCxfrom 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.

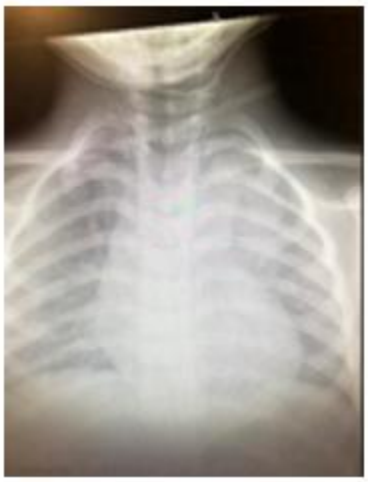

Figure 1: Plain radiograph of the patient's chest during initial admission revealing left upper lobe consolidation

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 (Figure 2a). The left upper lung zone showed hypo-echogenic air inclusions signifying a necrotic abscess (Figure 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(Figure 3). A follow up CT chest with contrast confirmed the diagnosis of a necrotizing cavitary lesion which was initially found on LUS (Figure 4).

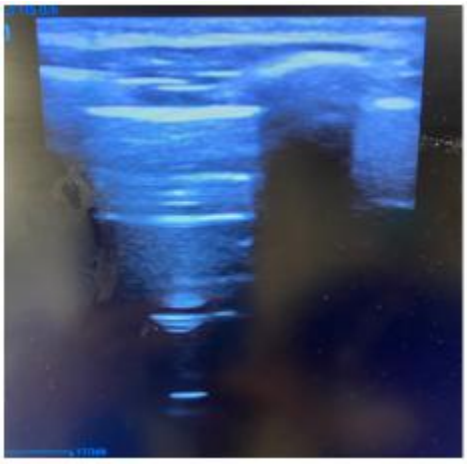

Figure 2a: Ultrasound of the patient's right lung in the emergency room showing normal lung echo pattern with a smooth pleural line and A-lines

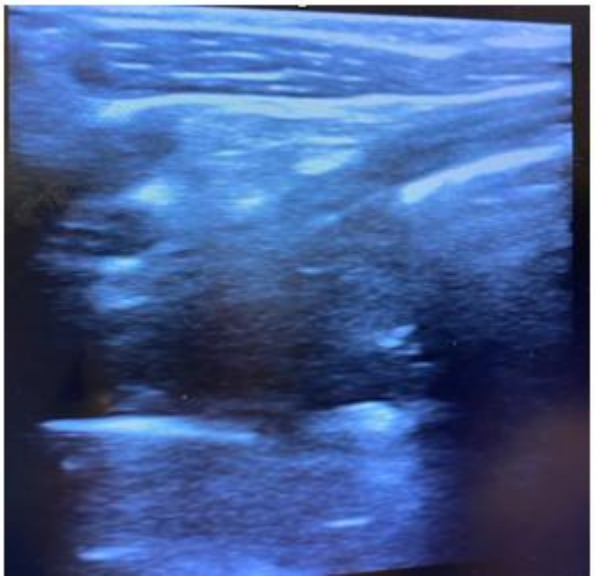

Figure 2b: Ultrasound of the patient's left upper lung zone revealing interstitial disease with necrotic change

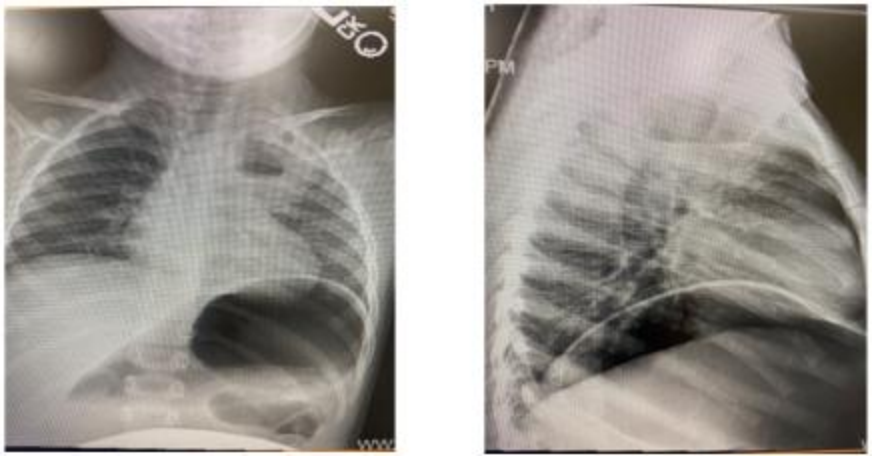

Figure 3: Plain radiograph of the patient's chest in AP and lateral views showing left upper lobe consolidation with lucency

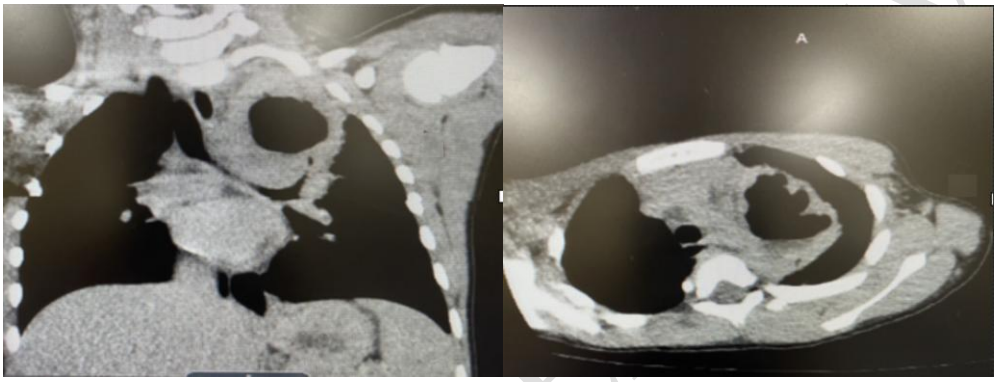

Figure 4: The patient's CT chest with contrast showing large gas and fluid containing collection in the left upper lobe with irregular wall confirming what was seen in ultrasound and CXR

The patient was given a dose of Ampicillin and Sulbactam and Vancomycin. A thirdblood 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 Tazobactamand Clindamycin following recommendations from infectious disease (ID). The thirdBCx 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 (Figure 5).

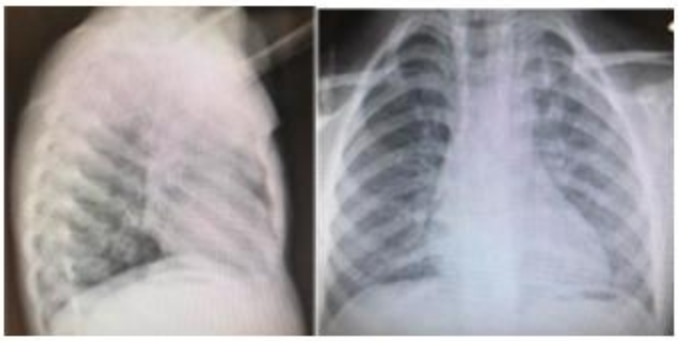

Figure 5: Pain radiograph of the patient's chest done prior to discharge showing improved mild residual density in the left upper lobe with no central lucency compared with Figure 3

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

Discussion:

Point of Care Ultrasound (POCUS) of the lung has been shown to be at least as sensitive as a CXR for the evaluation and diagnosis of pneumonia in the emergency room (5). While it is inexpensive and relatively fast, CXR has limitations when considering the diagnosis of pneumonia. Primarily it exposes the patient to ionized radiation, albeit very low doses, but radiation nonetheless. A negative CXR does not rule out the presence of interstitial disease and is not sensitive in detecting smaller lung consolidations (3). LUS is a safe imaging modality that can be used by providers when necrotizing pneumonia is suspected (4). The immediate availability and easy accessibility of LUS will allow for rapid diagnostic capability. However despite the growing evidence of accuracy and reliability as a diagnostic tool, generalized LUS usage in patients is still low. One of the reasons this may be is time constraints. Clinicians only have a certain amount of time allotted per patient and a scan can take up to 10 minutes (3). However, studies have shown that use of POCUS lung studies are more cost effective and decreased length of stay for ED patients compared to use of CXR (6). While ultrasound training is established in emergency medicine training, this is less so in primary care specialities such as pediatric residency. Pediatric trained physicians may have little to no training in POCUS at the time of graduation (7). POCUS lung evaluation is an easily teachable skill. Studies have shown that with short training times, as little as an hour, a novice sonographer is reliably able to diagnose abnormal lung findings (8). More emphasis should be placed on training practitioners in the usage of LUS. With accurate technique LUS can be sufficient in diagnosing necrotic lung lesions (4).

CT is commonly used on initial presentation when suspicious for NP and identifying hypoperfusion (9). However CT exposes the patient to unnecessary radiation, is very costly and at times requires sedation (4). Contrast used in CT has a risk of acute kidney injury in patients with reduced kidney function (10). The lack of contrast uptake in a CT with contrast is considered a supportive finding for NP. LUS in combination with doppler studies can be used to detect these same changes early in the pediatric patient (4). To perform an initial CT scan on all children with lung cavities is controversial because a proportion of these children require

repetitive imaging later on due to treatment failure which results in increased radiation exposure (9).

Conclusion:

Necrotizing pneumonia is a critical complication of CAP in children which should be a differential diagnosis in patients not improving on antibiotics (2). It is important to recognize necrotic changes on imaging. LUS is a beneficial tool in the initial diagnosis of NP and can be superior to CXR (4). There may be a place for usage of LUS instead of CXR or even CT in diagnosing NP in the ED. Further research is needed to ensure the validity of this substitution.

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