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Case Study

Emergency Point of Care ultrasound for early detection of Atypical Presentation of Pleural Effusion

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Abstract

Ultrasound has become an indispensable tool in modern emergency departments, significantly enhancing diagnostic accuracy, reducing patient waiting times, and facilitating the identification and treatment of life-threatening conditions. Point-of-care ultrasound (POCUS), which involves using ultrasound directly at the patient's bedside, has revolutionized the approach to emergency medicine. By using specific POCUS protocols for different organ systems, clinicians can deliver swift and accurate diagnoses, ensuring timely interventions. Among these protocols, the BLUE (Bedside Lung Ultrasound in Emergency) protocol is particularly effective in diagnosing lung-related conditions, such as pleural effusion. This case study highlights the critical role of POCUS in detecting atypical presentations of pleural effusion, a condition that can sometimes present in unconventional ways, complicating timely diagnosis. By recognizing specific signs during a lung ultrasound, clinicians can achieve an early and accurate diagnosis, ultimately leading to more effective interventions during resuscitation. Early detection of pleural effusion using the BLUE protocol can greatly improve patient outcomes, allowing for life-saving measures to be taken swiftly within the emergency department setting. We present a case where the identification of a particular sign during POCUS led to the early diagnosis of pleural effusion, enabling rapid intervention in a resuscitation scenario. This case underscores the significance of incorporating POCUS into emergency practice, as it enhances diagnostic capabilities and expedites treatment for critical conditions. The use of POCUS has the potential to save lives, particularly in high-stakes situations where time is of the essence.

Keywords: *BLUE Protocol; Emergency Medicine; Pleural Effusion; Point-of-care ultrasound*

Introduction

Pleural effusion is the abnormal accumulation of fluid within the pleural space, which can significantly impact respiratory function and overall health (Ferreiro *et al*., 2024). It occurs when there is an imbalance between the production and reabsorption of pleural fluid, typically due to conditions that alter the normal mechanisms of fluid movement, such as heart failure, infection, or malignancy (Sharma & Boster, 2024). The pleural cavity, normally containing a small amount of fluid for lubrication, can accumulate fluid when excess production outpaces its removal by the lymphatic system. The clinical presentation of pleural effusion can range from asymptomatic to severe, with patients potentially exhibiting symptoms such as shortness of breath, chest pain, and cough. However, symptoms may not always correlate directly with the underlying pathology, making diagnosis challenging (Gayen, 2022).

Diagnosing pleural effusion typically involves a combination of clinical evaluation, imaging studies, and laboratory investigations. Traditional diagnostic methods, such as chest X-rays and CT scans, are commonly employed, but they may not always provide immediate or definitive results, especially in

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emergency situations (Cascio *et al*., 2021). In emergency medicine, timely and accurate diagnosis is critical for managing conditions like pleural effusion, and bedside ultrasonography has emerged as a valuable modality. Point-of-care ultrasound allows for rapid, on-site assessment, making it particularly useful when the diagnosis remains unclear through conventional imaging techniques (Zaki *et al*., 2024).

Among the various signs observed in ultrasound, the Plankton sign is a key indicator that can help identify pleural effusion. This specific ultrasonographic finding has shown promise in providing early and accurate diagnosis, facilitating timely interventions in critical care scenarios. The ability to detect pleural effusion quickly in an emergency setting can significantly improve patient outcomes, underscoring the importance of ultrasound in modern diagnostic practices.

Case Description

A 62-year-old Malaysian Chinese gentleman with a significant history of chronic smoking (50 pack-years) and underlying medical conditions, including diabetes mellitus and dyslipidemia, presented to the emergency room (ER) with a chronic cough that had persisted for the past five years. Over the previous two weeks, he developed new constitutional symptoms, including a noticeable loss of appetite, unintended weight loss, and a marked worsening of shortness of breath. His reduced effort tolerance had reached a point where he required a walking aid to assist with mobility. Despite these symptoms, the patient reported no history of hemoptysis, night sweats, or exposure to tuberculosis (TB), and there was no family history of malignancy.

Upon clinical examination, the patient appeared mildly tachypneic, with a respiratory rate of 22 breaths per minute and an oxygen saturation of 96% on room air. Auscultation of the lungs revealed decreased breath sounds and diminished vocal resonance over the entire right lung field. A chest X-ray was performed, revealing a complete white-out of the right lung, a concerning finding that raised suspicion for pleural effusion. However, the X-ray did not provide definitive evidence for pleural effusion, as there were no typical radiographic signs such as the meniscus sign or fluid within the fissure.

Given the inconclusive chest X-ray, ultrasonography was performed as a bedside diagnostic tool, which revealed the plankton sign. This specific ultrasonographic finding, characterized by swirling internal echoes within an otherwise anechoic pleural effusion, became a key indicator suggesting pleural effusion. This was an important clue, as no other signs of pleural effusion, such as the thoracic spine sign or quad sign, were observed during the ultrasound examination.

With these clinical and imaging findings, diagnostic and therapeutic thoracentesis was promptly performed. During the procedure, 1.5 liters of hemoserous fluid were drained from the pleural space. A subsequent CT scan of the thorax revealed a large-volume right tension pleural effusion, which appeared to be malignant in nature. Additionally, the CT scan demonstrated significant bone changes in the T3 and T4 vertebrae, strongly suggestive of metastatic bone involvement, raising concerns for an advanced malignancy.

Despite receiving initial interventions, including oxygen therapy, continuous positive airway pressure (CPAP), and inotropic support, the patient's clinical condition continued to deteriorate. His shortness of breath worsened progressively, and he became increasingly dependent on respiratory support. Unfortunately, despite aggressive treatment, the patient ultimately succumbed to his illness, passing away due to complications related to the underlying disease.

This case underscores the critical role of point-of-care ultrasound in the emergency department, particularly in the diagnosis of atypical presentations of pleural effusion. In situations where traditional imaging modalities, such as chest X-ray, do not provide a clear diagnosis, ultrasonography can serve as a vital tool to confirm the presence of pleural effusion and guide subsequent clinical management. The use of the plankton sign in this case provided crucial information that led to the identification of pleural effusion, allowing for timely intervention. This highlights the value of bedside ultrasound in improving diagnostic accuracy, expediting treatment, and potentially saving lives in emergency settings.

Discussion

The plankton sign is a distinctive ultrasonographic finding seen in pleural effusion, characterized by the presence of floating debris within the effusion that appears as punctiform internal echoes. These echoes move dynamically with respiration or cardiac pulsations, providing valuable diagnostic information. The presence of the plankton sign strongly suggests that the effusion is likely exudative or hemorrhagic in nature, which can be critical in determining the appropriate management pathway for the patient (Bhoil *et al*., 2021). The dynamic nature of the sign, which responds to respiration or cardiac pulsations, enhances its diagnostic utility, particularly in real-time bedside assessments.

Research has demonstrated that when identifying exudative effusions, several ultrasound features, including fibrin strands, the plankton sign, septation, and loculations, exhibit a remarkable specificity of 97% and a positive predictive value (PPV) of 86% or greater. This makes ultrasound a highly specific modality in distinguishing between effusion types, particularly in cases where other imaging techniques may not offer clear differentiation (Ahmad *et al*., 2020). Moreover, the sensitivity and negative predictive value (NPV) of anechoic fluid for identifying transudative effusions are 94.1% and 92.1%, respectively, further supporting the role of ultrasound in evaluating pleural effusion characteristics.

The plankton sign is particularly valuable in identifying malignant effusions. Studies have shown that it has a specificity of 97.3% and a negative predictive value (NPV) of 88.4% for identifying cytology-positive malignancy (Ahmad *et al*., 2020). This high specificity and NPV values make the plankton sign a highly reliable indicator when malignancy is suspected, helping clinicians to determine the next steps in patient management. In fact, the plankton sign is almost exclusively seen in exudative effusions, with some studies indicating it as a potential marker for malignant pleural effusions (Chian *et al*., 2004). This adds an additional layer of diagnostic value, especially in patients with a history of smoking, as seen in the case presented, where malignancy was a key concern.

In this case, the identification of the plankton sign was crucial in differentiating the effusion type and pointing toward a malignant etiology, which was later confirmed through diagnostic thoracentesis and imaging. The dynamic ultrasound features allowed for rapid assessment, contributing significantly to the patient's management in the emergency department. While other ultrasound signs, such as the thoracic spine sign and quad sign, were absent, the plankton sign provided the necessary clue to proceed with further investigation and intervention.

It is also important to note that while combining various ultrasound features does not necessarily lead to an increase in the diagnostic performance for determining effusion type, the plankton sign, when present, can decisively influence clinical decision-making. The ability to use ultrasound for real-time, point-of-care diagnosis has proven to be an invaluable tool in emergency settings, enabling timely interventions that could potentially alter patient outcomes.

Figure 1: Plankton Sign

Conclusion

Airway assessment is a critical component of managing patients in the emergency department. Early Bedside ultrasonography plays a crucial role in the timely diagnosis and management of pleural effusion in emergency settings. By identifying key clinical signs such as the plankton sign, clinicians are able to make an accurate diagnosis and initiate prompt interventions. In this case, the detection of the plankton sign through ultrasound facilitated early diagnostic and therapeutic pleural tapping, which subsequently prompted the timely use of CT thorax for further evaluation. This early and targeted approach allowed the primary care team to provide more effective management, ultimately improving patient care outcomes (Figure 1).

The integration of point-of-care ultrasound (POCUS) into routine clinical practice holds significant promise for improving diagnostic accuracy and patient outcomes, particularly in emergency and critical care settings. Future advancements in ultrasound technology, along with further research into specific ultrasonographic signs like the plankton sign, may enhance its diagnostic capabilities and broaden its applications in detecting various types of pleural effusion. Additionally, the development of standardized protocols for ultrasound-based evaluation could help refine its role in early disease detection, reduce diagnostic delays, and guide more effective therapeutic interventions. Training healthcare professionals in the use of POCUS could further streamline decision-making processes, contributing to better patient management and overall healthcare efficiency.

Conflict of Interest

The authors affirm that there are no conflicting objectives.

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