CHEST

A 40-Year-Old Man With Respiratory Failure and Sepsis

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A 44-year-old man with a medical history of hypertension presented to the ED with 2 weeks of shortness of breath. On presentation, he was tachycardic, tachypneic, and hypoxemic with an oxygen saturation of 84% on room air. The polymerase chain reaction from his nasopharyngeal swab was positive for SARS-CoV-2. After admission to the ICU, his condition began to deteriorate clinically with worsening hypoxemic respiratory failure and required intubation. While on the ventilator, he experienced ARDS with dense consolidations and ground-glass opacities (Fig 1); his hospital course was complicated by bilateral pneumothoraces that required chest tubes. His clinical course was further complicated by worsening infection and rising inflammatory markers. Bedside ultrasound imaging was performed to evaluate the respiratory failure (Video 1).

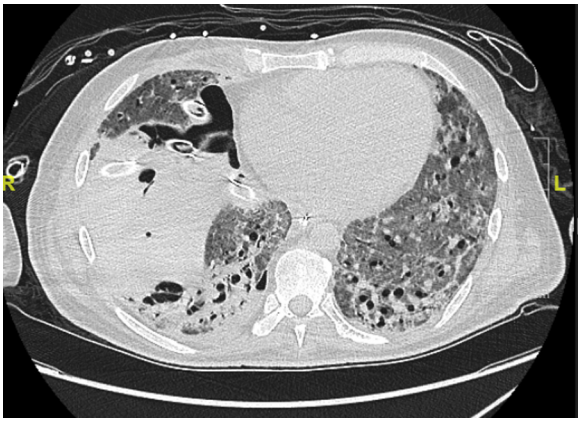

Figure 1 – *Right-sided loculated effusion with multiple chest tubes noted, extensive traction bronchiectasis, and ground-glass opacities.*

Question 1: Based on clinical history and ultrasound examinations, what is the clinical diagnosis of concern and what is the next step in treatment?

Question 2: Based on the imaging, what ultrasound strategy would help guide the catheter in the correct position?

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Answer 1: Empyema is of concern, given the presence of complex pleural effusion in the setting of pneumonia and worsening clinical condition. Sampling and drainage of the pleural space should be the next step in treatment. Placement of a chest tube or video-assisted thorascopic surgery may be considered to achieve this goal.

Answer 2: Real-time ultrasound guidance

A percutaneous technique chest tube was attempted after demarcation of the expected site of catheter entry. Aspiration from the needle did not yield pleural fluid (PF) or material, and the procedure was aborted. Repeat ultrasound examination revealed a thick, multiloculated effusion with septations and fibrin stranding (Fig 2).

Discussion

Chest ultrasound imaging is a growing field of interest, especially in the area of pleural disease. CT scanning traditionally has been the imaging modality of choice in critically ill patients, but it often comes with cost burden, significant radiation exposure, and transportation that may not be possible.[1] Ultrasonography, on the other hand, can be performed at bedside and does not expose patients to radiation. When made available, it can be a useful diagnostic tool in critically ill patients and offer information that other imaging modalities may not.[2,3]

Ultrasound examination can be used to help predict PF causes. Simple effusions appear anechoic, whereas complex effusions contain free-floating debris or plankton sign, fibrins, loculations, or diaphragm thickening.

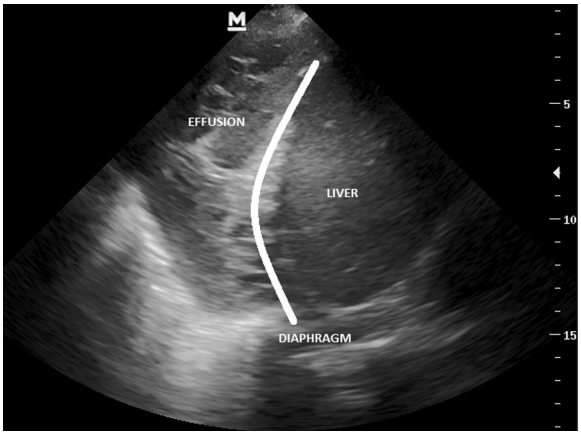

Figure 2 – *The complex, multiloculated pleural effusion is shown.*

Additionally, complex effusions are more likely to be exudative in nature.[4] Specific causes can be identified based on the appropriate clinical context and appearance of PF on ultrasound imaging. For example, Flora et al[5] showed the presence of hematocrit and plankton sign as suggestive of a hemothorax in the correct clinical context.

In the presented case, the use of bedside ultrasound imaging allowed for optimal viewing of the pleural space and determination of the anatomic barriers to drainage. As shown in Figure 1, CT scans demonstrated a complicated-appearing pleural space along with parenchymal disease, but it was difficult to discern the anatomic demarcations between fluid and parenchyma or determine a cause. Ultrasound imaging was able accurately to demonstrate a complex, exudative-appearing effusion with numerous fibrins and septations, highly concerning for an empyema. Furthermore, with the use of ultrasound imaging, a definitive pocket of fluid was identified in the pleural space that was amenable for direct sampling and potential drainage. Given the complexity of the fluid and the thick nature, it was difficult to aspirate from the pleural space, making for ambiguity of catheter placement by using the Seldinger technique. To support this procedure in a more controlled fashion, a second successful attempt at catheter placement used real-time guidance by ultrasound imaging.

The ultrasound probe was dressed in a sterile sheath, and real-time ultrasound guidance was used to control the access into the pleural space. Ultrasound imaging from the key steps of the procedure are shown in Video 2. Ultrasound-controlled insertion of the needle yielded 50 mL of thick purulent material. Needle tip was confirmed within the pleural space by the injection of sterile saline solution. The guidewire was confirmed similarly within the target material. Further treatment was guided by serial chest ultrasound evaluation, where the complex appearance of the pleural effusion and the inadequate evacuation of the pleural space with the catheter alone suggested the need for fibrinolytics. Fibrinolysis was achieved by instillation of alteplase and dornase alfa via the port of the chest tube into the pleural space, which facilitated further drainage of the PF. Analysis and microbiologic evidence of the PF confirmed empyema with multidrug-resistant *Enterobacter cloacae*. After antibiotics and source control of the empyema by way of pleural drainage, the patient recovered from sepsis.

A prospective study by Rodriguez Lima et al[6] analyzed the use of real-time ultrasound guidance for

thoracentesis and found that this procedure improved oxygenation and yielded fewer complications after the procedure (1.2%) compared with landmark technique aspiration of PF (10% to 18%). Another study by Helgeson et al[7] demonstrated that thoracenteses and chest tubes that used real-time ultrasound guidance, when compared with standard of care ultrasound-marked procedures in which the location of the procedure was found with ultrasound imaging but not used during the procedure, had a significantly lower rate of iatrogenic pneumothoraces.

Further investigation into real-time ultrasound procedures is needed to assess its safety and efficiency, but it appears to be an adjunctive tool in select cases of pleural access procedures, as illustrated by the literature and by the case presented here.

Reverberations

1. *Ultrasound imaging can be used to better characterize quality of PF, which can be used to direct treatment.*
2. *Real-time ultrasound guidance can be used to ensure adequate entry into pleural space, especially in cases of viscous fluid that are not easily free flowing.*
3. *Real-time ultrasound-guided procedures may also be a safer modality than standard of care ultrasound-marked procedures.*

Acknowledgments

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Additional information: To analyze this case with the videos, see the online version of this article.

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