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CHEST

A Patient With Coronavirus Disease 2019 Pneumonia and Sudden Decompensation While Receiving Mechanical Ventilatory Support

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A 52-year-old man sought treatment for nonproductive cough, fever, and worsening shortness of breath. On admission, he was in respiratory distress with oxygen saturation at 73% on room air. His admission chest radiograph is shown in Figure 1. The patient was admitted with coronavirus disease 2019 (COVID-19) pneumonia, which was confirmed by PCR antigen testing. Four days after admission, the patient required endotracheal intubation for progressive hypoxemic and hypercapneic respiratory failure.

On day 10 of medical ICU (MICU) care, the patient developed right anterior chest wall and neck subcutaneous emphysema with severe oxygen desaturation and hypotension requiring escalating doses of vasopressors. The plateau pressure was measured as 80 cm H_2O. Urgent lung ultrasound examination showed multiple areas of confluent B lines over the left anterior chest. Because of the right-sided subcutaneous air, adequate right lung ultrasonography images could not be obtained. The MICU team performed a needle decompression through the right anterior second intercostal space with audible decompression of a tension pneumothorax followed by insertion of a 16F chest tube. BP improved, although the patient still required vasopressor support. Plateau pressure decreased to 50 cm H_2O, which was above the baseline value of 30 cm H_2O.

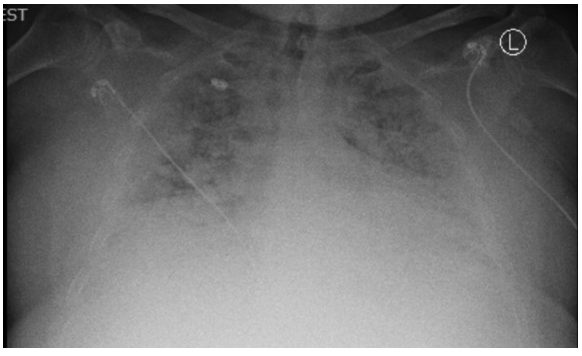

Figure 1 – *Admission chest radiograph demonstrating diffuse bilateral opacities.*

Concurrent with these events, the patient developed severe abdominal distention with a bladder pressure of 25 mm Hg. Given the persistent hemodynamic failure, elevation of plateau pressure, and intraabdominal hypertension, the MICU team performed an abdominal ultrasound examination (Video 1).

Question: Based on the clinical history and ultrasound findings, what is the diagnosis and next step in management?

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Answer: The abdominal ultrasound findings are consistent with the presence of a large pneumoperitoneum. The absence of gut sliding and the inability to visualize any underlying structures within the abdomen suggest that free air is interposed between the ultrasound probe and the peritoneal space. Given the patient's shock state, elevation of plateau pressure, and intraabdominal hypertension, the MICU team established a diagnosis of abdominal compartment syndrome. This was managed by insertion of an ultrasound-guided catheter into the air-filled peritoneal space.

Discussion

The patient presented with ARDS due to COVID-19 pneumonia. Ten days after initiation of ventilatory support, he developed a tension pneumothorax, which was treated by needle decompression followed by chest tube placement. Despite this intervention, the patient remained hypotensive with elevated plateau pressures.

Given the patient's abdominal distention, an abdominal ultrasound examination was performed, which demonstrated air reverberation artifact throughout all four quadrants of the abdomen consistent with a large pneumoperitoneum (Video 1). This was confirmed by chest radiography (Fig 2). A diagnosis of abdominal compartment syndrome was made on the basis of persistent hypotension, elevation of plateau pressure, and a bladder pressure of 25 mm Hg.[1]

An 8.3F pigtail catheter was inserted through the right upper quadrant under ultrasound guidance for decompression of the pneumoperitoneum (Figs 3A and 3B). Insertion of the catheter resulted in audible decompression. BP and oxygen saturation improved, plateau pressure dropped from 50 to 30 cm H_2O, and bladder pressure was reduced to 12 mm Hg (Discussion Video).

The most common cause of pneumoperitoneum is a perforated viscus. Five percent to 15% of cases have an alternative cause that may be categorized as thoracic, abdominal, gynecologic, or idiopathic.[2] Ventilator-induced barotrauma is the leading thoracic source of pneumoperitoneum.[3] There is an established association between pneumothorax and pneumoperitoneum,[2,4,5] for which there are two proposed mechanisms. The pneumoperitoneum may result from movement of air directly from the pleural space into the peritoneum

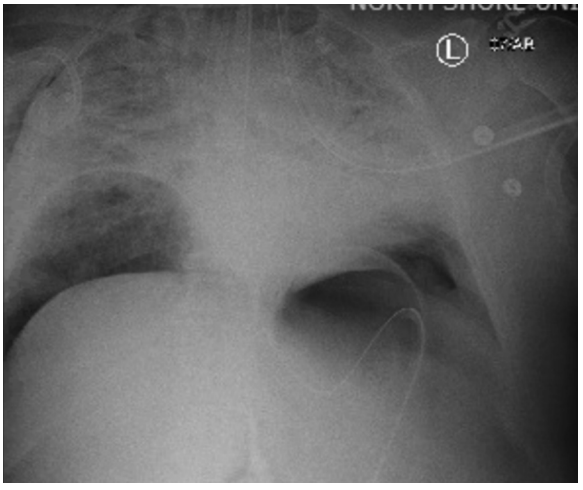

Figure 2 – *Chest radiograph taken after right anterior chest tube placement. Note right thoracic subcutaneous emphysema and the presence of free intraabdominal air.*

through defects within the diaphragm. Alternatively, air may track along the bronchovascular bundle from the alveolar space into the mediastinum, resulting in pneumothorax and occasionally pneumoperitoneum.[2]

Visualization by ultrasound of an intraabdominal organ or the presence of gut sliding rules out pneumoperitoneum at the site of probe application.[6] This is analogous to the use of lung ultrasound to rule out pneumothorax. The visualization of B lines, consolidation, or pleural effusion, or the presence of lung sliding rules out pneumothorax at the site of probe application. Similarly, although suggestive of pneumoperitoneum in the appropriate clinical context, a lack of gut sliding does not indicate the amount of free air that is present.

In reference to the present patient, in whom there was a large amount of intraabdominal free air, intraabdominal organs were not visible and gut sliding was not present. In addition, there were multiple reverberation artifacts that were consistent with the presence of free air.

The detection of smaller amounts of intraabdominal free air is well described in the literature.[7-9] A meta-analysis evaluating the detection of pneumoperitoneum by ultrasound demonstrated a pooled sensitivity of 0.91.[10] Ultrasonography was shown to be superior to plain radiography in the detection of pneumoperitoneum in 188 patients with suspected hollow organ perforation.[11] Small amounts of free air appear as a localized echogenic area with posterior reverberation artifact.[7] A characteristic feature of a localized collection of free air is enhancement of the peritoneal interface at the site of the air collection. This is associated with a posterior

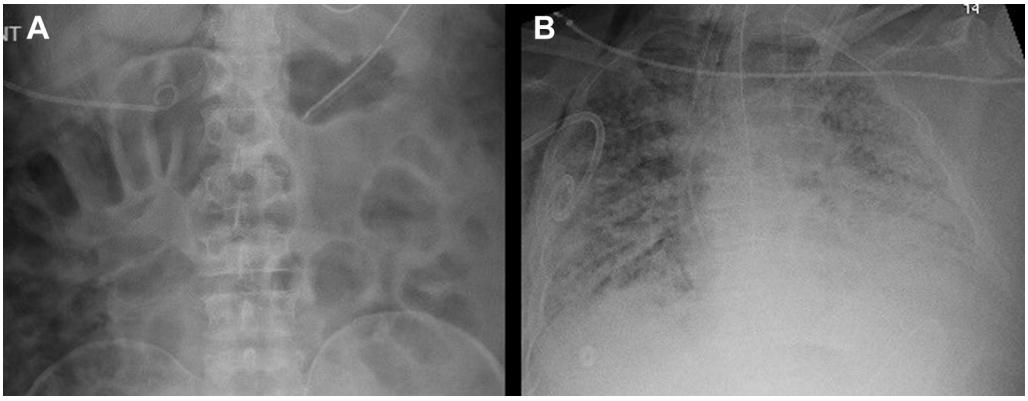

Figure 3 – *A, Abdominal radiograph confirming placement of right upper quadrant catheter within the peritoneal space. B, Chest radiograph demonstrating resolution of the pneumoperitoneum.*

reverberation artifact resulting from the air-tissue interface that is created by presence of free air. This phenomenon is termed the enhanced peritoneal stripe sign.[12] These findings were not present in the described case because of the large size of the pneumoperitoneum.

Pneumoperitoneum that is not due to a perforated viscus may be managed conservatively. If there is a concern for abdominal compartment syndrome, decompression is indicated.[3,13,14] Although percutaneous drainage may be appropriate in an emergency, in the setting of complex abdominal disease an open approach should be considered.

In the present case, the patient developed a tension pneumothorax in association with a tension pneumoperitoneum. This required decompression of both the pleural and peritoneal spaces that resulted in improved hemodynamic status, gas exchange, and respiratory system compliance.

This case demonstrates that ultrasound can be used to rapidly diagnose a large pneumoperitoneum and to safely guide percutaneous drainage when emergency decompression is indicated.

Reverberations

1. *Pneumoperitoneum may occur in conjunction with pneumothorax.*
2. *Free intraperitoneal air can be rapidly identified by ultrasound.*
3. *Percutaneous drainage in the setting of a large tension pneumoperitoneum with abdominal compartment syndrome may be performed under ultrasound guidance.*

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

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