Case Report

Spectrum of Barotraumatic Events in COVID-19 Patients on High-Resolution Computed Tomography

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Abstract

Barotrauma has many different presentations, including pneumothorax, subcutaneous emphysema, pneumoperitoneum, and pneumomediastinum. We have presented and analyzed some interesting cases of barotrauma in this case series. Case 1 in our series developed a thin-walled new cavity due to barotrauma, mimicking pneumatocele and fungal cavity. Case 2 presented with coexistence of pneumothorax and cavity with fungal infestation. Severity of barotrauma due to positive pressure ventilation has been shown in case 3. An interesting case of barotrauma in a 36-week primigravida, post cesarean section, causing dehiscence of scar, presented as case 4 in our series. Early and rapid imaging diagnosis of barotrauma should be pursued. In patients with mechanical ventilation, identifying small changes in imaging characteristics of cavitary lesions, such as fungal, bacterial, or transient cavities, would aid physicians in offering a correct treatment plan.

Keywords: Barotrauma, mechanical ventilation, pneumomediastinum, pneumothorax, subcutaneous emphysema

Introduction

COVID-19-associated hypoxemic respiratory failure and acute respiratory distress syndrome (ARDS) were recorded in the literature as death rate (2%–13%), reaching up to 15% in patients needing mechanical ventilation.[1-3] More recently, pulmonary barotrauma (PBT), which includes subcutaneous emphysema, pneumothorax, and pneumomediastinum, has been seen in 15% of ventilated patients.[4] Varied presentations of the effects of barotrauma in coronavirus disease (COVID-19) patients posing a diagnostic dilemma have been presented.

Case Report

Case 1 – Development of a thin-walled new cavity due to barotrauma, mimicking pneumatocele and fungal cavity

A 71-year-old COVID-positive, diabetic male with acute dyspnea was admitted to the intensive care unit and placed on noninvasive positive pressure ventilation. A computerized tomography (CT) scan done on the 2nd day revealed diffuse areas of patchy ground-glass opacities (GGOs) and consolidation involving all the lobes of both lungs with a CT severity score of 21/25. Pneumomediastinum was also noted [Figure 1a]. With worsening of symptoms, another CT was done on the 7th day of admission which revealed newly developed pneumothorax [Figure 1b]. With appropriate management, the patient's clinical state improved and a 20th-day CT scan revealed complete resolution of the pneumothorax and pneumomediastinum. Interestingly, there was fresh development of a new cavity with a tiny mural nodule in the anterior segment of the right upper lobe mimicking pneumatocele or fungal infestation [Figure 1c]. Culture test was negative for bacterial or fungal etiology. Follow-up CT scan after 3 months revealed complete resolution of the cavity [Figure 1d] without any residual signs.

Case 2 – Coexistence of pneumothorax and cavity with fungal infestation

A 52-year-old reverse transcription polymerase chain reaction (RT-PCR)-positive male patient was admitted with breathlessness, sore throat, and cough for 4 days. He was

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a known diabetic for more than 10 years and was on oral hypoglycemic drugs. After admission, he was treated with intravenous antibiotics, steroids, antiviral and multivitamins, as well as general supportive care. To avoid thrombotic problems, he was also given subcutaneous enoxaparin twice a day. His diabetes was controlled with insulin doses adjusted on a sliding scale. Due to worsening of symptoms and inability to maintain SpO_2 above 90%, he was subjected to mechanical ventilation. High-resolution computerized tomography (HRCT) thorax revealed collapse and consolidation with diffuse GGOs in all lobes of bilateral lung fields. Bilateral pneumothorax (right > left) was also noted [Figure 2a]. Irregularly marginated cavitary lesion was seen in the right middle lobe with few internal septations pointing toward the possibility of fungal infective etiology [Figure 2a and b]. Sputum for acid-fast bacilli was negative. Culture for the fungal infection revealed *Candida tropicalis*. He was treated with antifungal medications and was discharged after 21 days of admission after improvement of clinical condition.

Case 3 – Severe barotrauma in a patient kept on positive pressure ventilation

A 56-year-old male, known diabetic and hypertensive, was brought to our hospital with worsening of shortness of breath. Baseline HRCT showed diffuse GGO and consolidation in bilateral lungs with a CT severity score of 20/25 [Figure 3a and c]. The patient was mechanically ventilated with lung-protective ventilation. These strategies included a low tidal volume (V_T) of 4–8 mL/kg predicted body weight, a volume-limited assist-control mode, and an initial positive end-expiratory pressure of 5 cm H_2O that was gradually increased to improve oxygenation while aiming for a plateau pressure of 30 cm H_2O to avoid lung injury. Even after applying proper ventilation protocols, within 3 days of intubation, repeat CT thorax showed severe barotrauma in the form of pneumomediastinum, pneumothorax, and subcutaneous emphysema [Figure 3b and d]. Subcutaneous emphysema was so severe that it involved chest wall extended up to the neck, face, and periorbital skin superiorly, along subcutaneous regions of bilateral arms laterally, and extended up to anterior abdominal, pelvic, and scrotal walls inferiorly [Figure 3e-i]. Pneumoperitoneum was also noted. Despite all efforts, the patient was unable to be revived and was proclaimed dead on the 17th day of admission.

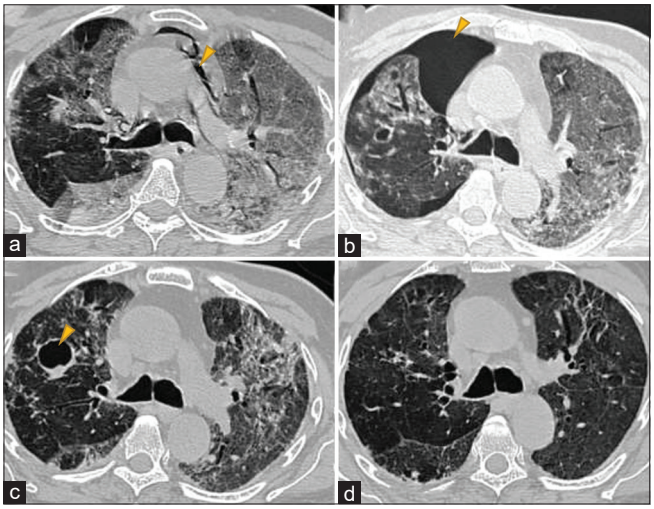

Figure 1: The axial high-resolution computerized tomography slices of case 1 show: (a) Significant consolidation and ground-glass opacities in both lungs with pneumomediastinum (arrowhead). (b) He developed pneumothorax on repeat computerized tomography after 7 days of admission (arrowhead). (c) A 20-day computerized tomography scan revealed complete resolution of the pneumothorax and pneumomediastinum, but a new cavity had developed in the anterior portion of the right lung (arrowhead). (d) The patient followed up after 3 months revealed complete resolution of cavity with mild residual fibrosis in both lungs

Case 4 – Barotrauma in a 36-week primigravida causing dehiscence of scar, post cesarean

A 29-year-old COVID-positive 36-week primigravida was admitted to our hospital with severe breathlessness, cough, vomiting, and fever for 6 days. Clinically, subcutaneous emphysema was felt in the neck region. The patient's clinical state was deteriorating with every passing hour, therefore, immediate lower-segment cesarean section (LSCS) was recommended to rescue the newborn at the very least. The surgery was done successfully. Despite the increased risk of barotraumatic events due to the presence of already existing subcutaneous emphysema, the patient was intubated and put on invasive mechanical ventilation keeping in mind the risk versus benefit approach. The next day, after the successful LSCS, a CT thorax was done to confirm the extent of subcutaneous emphysema, any other barotraumatic events such as pneumothorax or pneumomediastinum, as well as to determine the severity of lung involvement due to COVID. CT thorax revealed diffuse subcutaneous emphysema extending from the bilateral chest wall to the bilateral neck region, along with mild pneumomediastinum and minimal pneumothorax on the left side [Figure 4a-d].

Subsequently, the patient developed abdominal distension for which CT abdomen was done, which revealed gross pneumoperitoneum [Figure 4e-g]. No obvious defect was noted in bowel loops ruling out bowel perforation. However, cesarean scar was dehiscent with a defect of size about 2.7 cm through

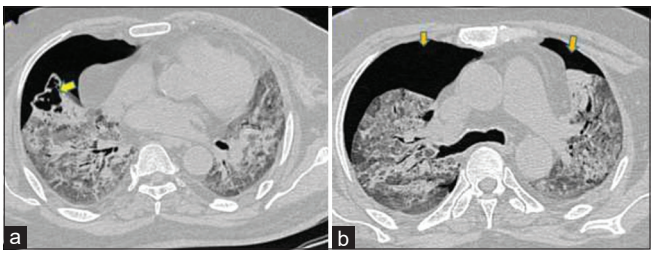

Figure 2: (a) Axial high-resolution computerized tomography thorax showing small cavitary lesions with few internal septations and tiny soft-tissue nodular opacities with in (Yellow arrow in A). Sputum culture revealed *Candida* species. (b) Bilateral pneumothorax can be seen (orange arrows in b)

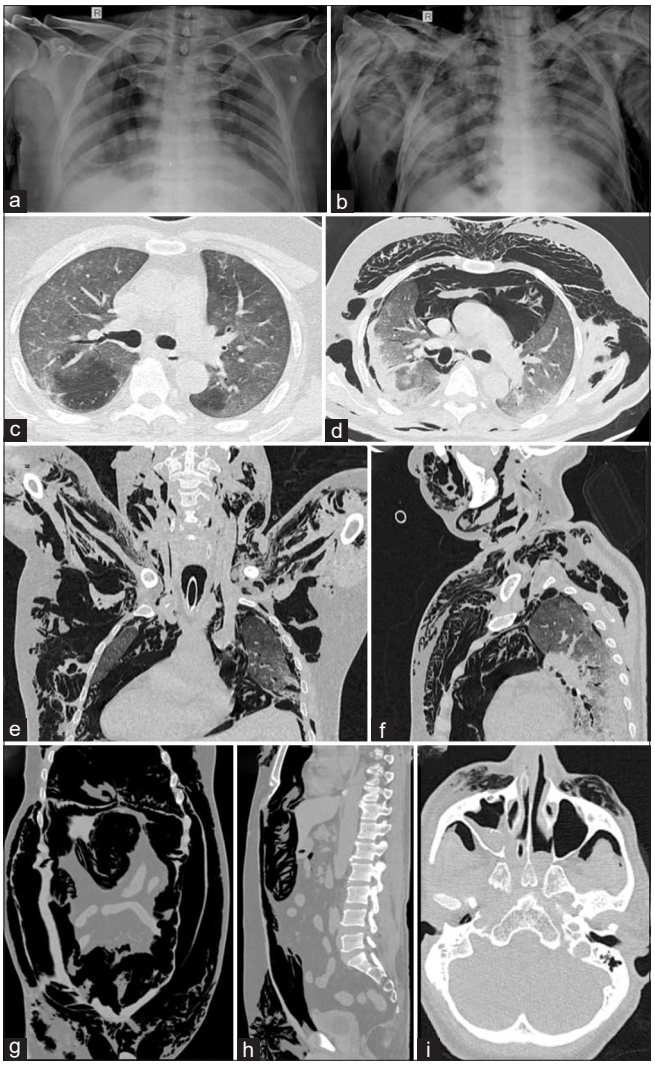

Figure 3: (a and c) are the baseline X-ray and computerized tomography axial images of case 3 showing diffuse ground-glass opacities and consolidation without the evidence of barotraumatic event. (b and d) The images taken after 3 days of intubation showing subcutaneous emphysema and pneumomediastinum. (e-i) Coronal, sagittal, and axial sections at different levels showing extensive subcutaneous emphysema involving face, neck, proximal arms, chest, abdomen, pelvis, and scrotal wall

which the subcutaneous emphysema was seen communicating with the intra-abdominal air [Figure 4e].

A line diagram showing the mechanism of barotraumatic events in these four patients kept on mechanical ventilation is shown in Figure 5.

Discussion

PBT was found in 10%–14% of COVID-19-infected, mechanically ventilated ARDS patients.[4,5] Martinelli *et al*. found that around 25% of intubated patients acquired pneumothorax or pneumomediastinum.[6] When invasive ventilation is utilized, ARDS has been established as an independent risk factor for barotrauma. In the literature, the

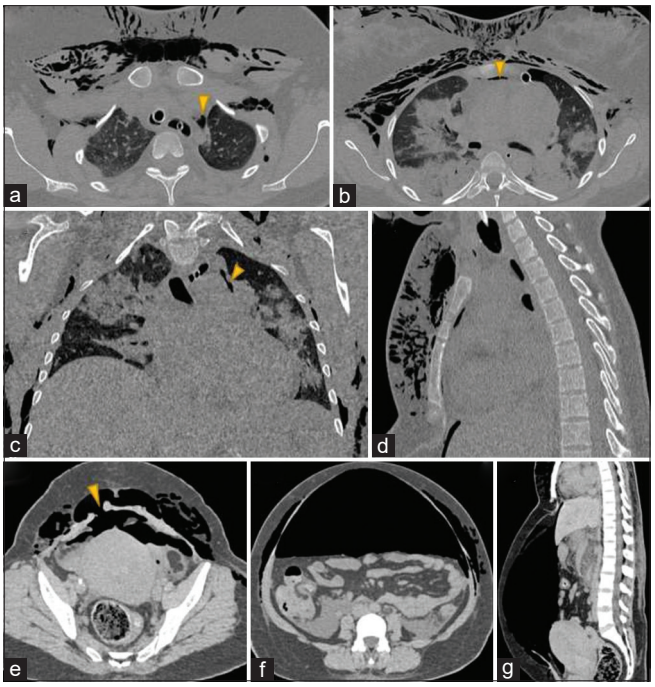

Figure 4: (a-d) Axial, coronal, and sagittal sections of case 4 showing subcutaneous emphysema and pneumomediastinum (arrowheads). (e) Noncontrast CT (NCCT) axial section showing dehiscence of cesarean scar (arrowhead) with communication between subcutaneous emphysema and intra-abdominal air. (f and g) Axial and sagittal sections showing gross pneumoperitoneum

incidence of ARDS has been reported to fluctuate, with some studies showing rates as high as 15%.[7,8] de Lassence *et al*. discovered that patients who developed barotrauma had a much greater mortality rate (72.9%) than those who did not develop barotrauma (39.73%).[9] Barotrauma can happen due to natural progression of the disease also. In our study, all the four patients who had barotrauma were suffering from ARDS.

In our first case, pneumothorax and pneumomediastinum developed as a result of barotrauma caused by mechanical ventilation. The emergence of a new cavitary lesion in this case was intriguing, as it cast doubt on whether the cavity was pneumatocele or owing to fungal infection, or as a result of mechanical ventilation. A bacterial or fungal infection was not found in the culture. A follow-up scan after 3 months, revealed full cavity clearance, indicating that cavity was transitory and was caused by positive pressure ventilation, which resolved on its own once the ventilator support was withdrawn. The possible mechanism of development and resolution of cavitary lesion after withdrawal of positive pressure ventilation may be explained by endobronchial check valve mechanism which allows air trapping and development of distal air space cyst.[10]

Similarly, in our second case, we discovered a large cavitary lesion with uneven and nodular internal borders, along with barotraumatic phenomena such as pneumothorax. It was difficult to ascertain if the lesion was a pneumatocele, or due to fungal infection. *Candida* species was identified in the culture. Hence, the cavity may have been caused by invasive

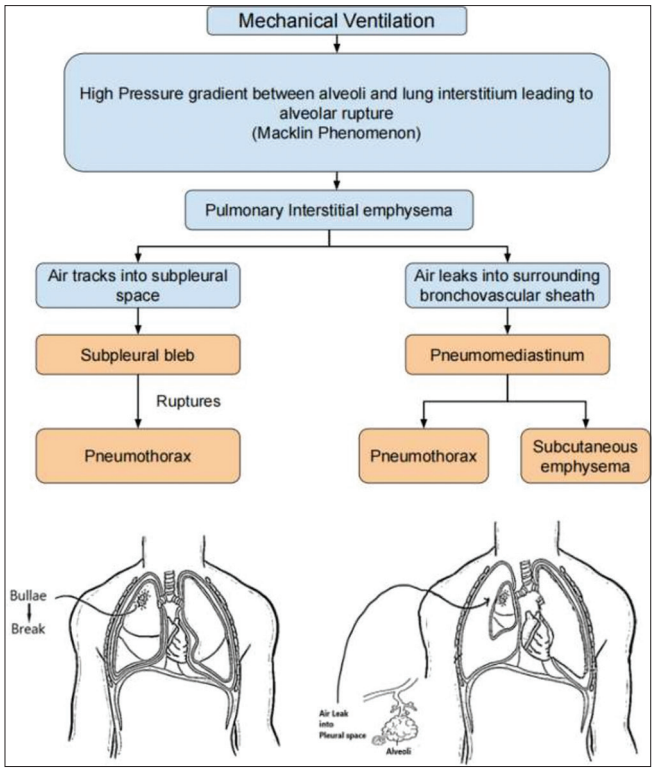

Figure 5: A line diagram showing mechanism of barotraumatic events in these four patients kept on mechanical ventilation

candidiasis or by persistent barotrauma with superadded fungal infection.

The severity of barotraumatic events was demonstrated in case 3 of this series. Even when adequate ventilation protocols were followed, subcutaneous emphysema had progressed to the point that it had affected the face, neck, bilateral forearms, chest, abdomen, pelvis, and scrotal wall. Pneumothorax, pneumomediastinum, and pneumoperitoneum were also present. The patient died as a result of all of these severe barotraumatic episodes. Similarly, in case 4 of our series, the consequence of barotrauma was so severe that the cesarean scar ruptured. Pneumomediastinum, pneumothorax, and subcutaneous emphysema before cesarean delivery might be caused by increased intrathoracic pressure during pregnancy (Hamman syndrome), COVID, or a combination of the two.

Conclusions

Ventilation-induced transient cavitary lesions should be kept in mind in COVID pandemic. Early and fast radiological diagnosis of barotrauma should be pursued during aggressive management protocols. Identification of minor variations in imaging features of cavitary lesions, such as fungal, bacterial, or transitory cavities, in patients with mechanical ventilation, will help the clinicians in providing accurate treatment protocol.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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