

# Pulmonary barotrauma in acute respiratory distress syndrome: A case of subcutaneous emphysema, pneumomediastinum, and pneumothorax

Kirsten M Lipps, Anatoliy V Nechyporenko

## CASE REPORT

A 57-year-old woman with chronic obstructive pulmonary disease (COPD), decompensated cirrhosis, and hepatopulmonary syndrome developed severe acute respiratory distress syndrome (ARDS) of presumed viral etiology. The patient was intubated and mechanically ventilated for management of hypoxemic respiratory failure. During a standard interruption of sedation on Hospital Day 5, the patient self-extubated. She was initially supported with non-invasive positive pressure ventilation, but she developed recurrent, progressive, hypoxemic respiratory failure. Thus, she was electively re-intubated and mechanically ventilated on Hospital Day 11.

Shortly after re-intubation, the patient had evidence of pulmonary barotrauma, with mild crepitus in her chest. This rapidly progressed to overt distention of her face, neck, trunk, and extremities. Radiographic (Figure 1) and computed tomographic (Figures 2, 3A and B) imaging following re-intubation demonstrated diffuse subcutaneous emphysema, a large pneumomediastinum, and a small, right-sided pneumothorax. The extensive pulmonary barotrauma was presumed due to alveolar rupture, precipitated by reduced lung compliance, which is characteristic of severe ARDS. However, direct airway trauma, particularly related to endotracheal tube removal by the patient, could not be entirely excluded.

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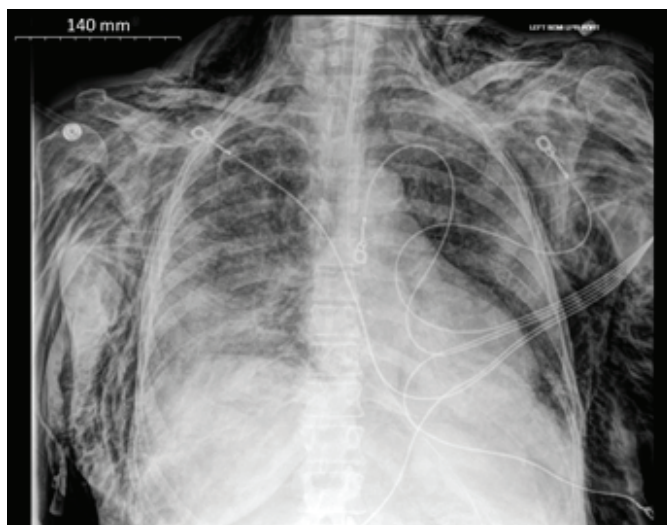


Figure 1: Chest X-ray, anteriorposterior. Diffuse striated lucencies throughout the soft tissues, consistent with extensive subcutaneous emphysema.

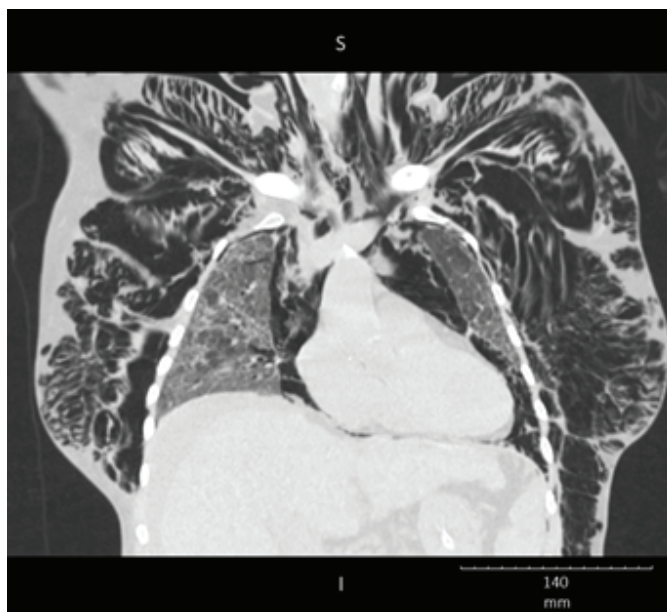


Figure 2: Chest CT, coronal plane. Diffuse subcutaneous emphysema, large pneumomediastinum, and trace bilateral pneumothoraces.

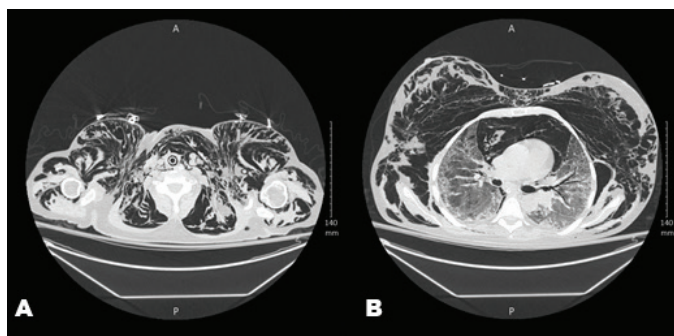


Figure 3: Chest CT, axial plane. (A) Diffuse subcutaneous emphysema extending into bilateral upper extremities and neck. (B) Large pneumomediastinum, small left pneumothorax, and diffuse ground glass opacities of lung parenchyma.

Although manifestations of the patient's pulmonary barotrauma were apparent clinically and radiographically, her hemodynamic status and pulmonary mechanics were unaffected. Consequently, the patient was managed conservatively with lung-protective mechanical ventilation and remained hemodynamically stable. However, she developed progressive lung injury related to severe ARDS, which was refractory to salvage therapies, including deep sedation, neuromuscular paralysis, prone positioning, high-dose glucocorticoids, and inhaled epoprostenol. Four weeks after admission, the patient was terminally extubated and expired.

## DISCUSSION

Pulmonary barotrauma is caused by alveolar rupture in the setting of elevated trans-alveolar pressures. The consequences of an extrapulmonary air leak include subcutaneous emphysema, pneumothorax, pneumomediastinum, and pneumoperitoneum [1]. The incidence of pulmonary barotrauma is estimated between 2% and 10% and varies based on the presence of underlying pulmonary disease [2]. The incidence in ARDS patients is approximately 10% [2–4]. Positive-pressure mechanical ventilation is the most important risk factor leading to the development of pulmonary barotrauma [5]. However, underlying pulmonary disease is also typically present in patients who develop this complication. Disease processes associated with reduced lung compliance and/or dynamic lung hyperinflation increase the risk for development of pulmonary barotrauma. Decreased compliance is typical of ARDS, pneumonia, and interstitial lung disease, whereas hyperinflation is seen in COPD and asthma [2, 6].

Early recognition of pulmonary barotrauma is essential for prevention of hemodynamic and respiratory collapse. For patients who develop pneumothorax or pneumomediastinum, pulmonary barotrauma is typically diagnosed via imaging. Plain chest radiography is first line, though in mechanically ventilated patients, free

air may accumulate in atypical locations due to supine or semi-recumbent positioning. Further, pneumothorax and pneumomediastinum may be obscured by the presence of extensive subcutaneous emphysema. In such cases, chest computed tomography may be required for diagnosis. Pulmonary barotrauma may also be diagnosed clinically, particularly in patients with extensive subcutaneous emphysema. For patients with a non-tension pneumothorax, clinical signs include absent or reduced unilateral breath sounds, acute increase in peak and plateau pressures, decrease in expired tidal volume, and patient–ventilator dyssynchrony.

Although rare cases of tension pneumomediastinum and compartment syndrome have been reported, most incidences of pulmonary barotrauma are well tolerated [7]. Conservative management focuses on treating underlying pulmonary disease and utilizing lung-protective mechanical ventilation strategies. Plateau pressure, which is the pressure applied to the small airways and alveoli, should be limited to 35 cm H<sub>2</sub>O or less, as higher values are associated with the development of pulmonary barotrauma [8, 9]. Low tidal volumes are also an important component of lung-protective mechanical ventilation. However, large randomized controlled trials have failed to demonstrate a reduction in the incidence of pulmonary barotrauma in ARDS patients ventilated with low tidal volumes [4, 10, 11]. For patients with obstructive lung disease, avoidance of dynamic hyperinflation is critical, as elevated *intrinsic* positive end-expiratory pressure (PEEP) increases plateau pressure. In contrast, high levels of *extrinsic* PEEP are not associated with a higher incidence of pulmonary barotrauma [3, 12].

Pulmonary barotrauma typically has minimal effect on cardiorespiratory status and is rarely a direct cause of mortality. However, pulmonary barotrauma is associated with poor overall prognosis for patients with ARDS, as it occurs with greater frequency in patients with severe lung injury [13, 14]. Consequently, early identification and targeted management of the etiology of ARDS are essential to prevent irreversible lung injury.

## CONCLUSION

Pulmonary barotrauma is precipitated by positive-pressure mechanical ventilation in the setting of underlying lung disease. It occurs in approximately 10% of mechanically ventilated patients with ARDS. Although cases of pulmonary barotrauma may be clinically and radiographically striking, this complication typically has minimal effect on hemodynamic or pulmonary mechanic parameters. Conservative management is standard of care in stable patients and focuses on treating underlying pulmonary disease and utilizing lung-protective mechanical ventilation strategies. Pulmonary barotrauma is rarely a direct cause of mortality but is a poor prognostic marker in patients with ARDS, as it most often occurs in patients with severe underlying lung injury.

**Keywords:** Acute respiratory distress syndrome, Mechanical ventilation, Pulmonary barotrauma

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**Author Contributions**

Kirsten M Lipps – Conception of the work, Design of the work, Acquisition of data, Interpretation of data, Drafting the work, Revising the work critically for important intellectual content, Final approval of the version to be published, Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

Anatoliy V Nechyporenko – Conception of the work, Design of the work, Acquisition of data, Interpretation of data, Drafting the work, Revising the work critically for important intellectual content, Final approval of the version to be published, Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

**Guarantor of Submission**

The corresponding author is the guarantor of submission.

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**Consent Statement**

Written informed consent was obtained from the patient for publication of this article.

**Conflict of Interest**

Authors declare no conflict of interest.

**Data Availability**

All relevant data are within the paper and its Supporting Information files.

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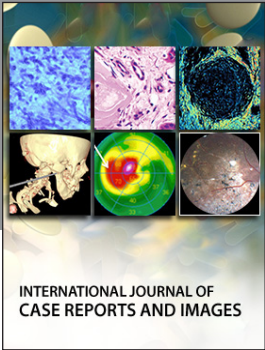
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