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When a Perfect Storm is Awaiting to Strike: Advanced Adenocarcinoma of the Lung Origin, Tension Pneumothorax, Bronchopleural Fistula, Polymicrobial Sepsis, Invasive Aspergillosis, and Renal Failure

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Abstract

Background: Patients with advanced lung malignancy are vulnerable to disastrous pulmonary complications, especially when structural tumor necrosis, infections, and critical illness intersect. Bronchopleural fistula (BPF), persistent pneumothorax, and invasive fungal infection are rare but often fatal. Case Presentation: We report a 60-year-old man with recently diagnosed lung adenocarcinoma who presented with acute hypercapnic respiratory failure, hypertensive crisis, and severe leukocytosis. Initial imaging revealed diffuse multifocal pneumonia. Despite starting non-invasive ventilation, he required intubation, which was complicated by a large right-sided tension pneumothorax and persistent air leak requiring chest tube placement. His hospital course rapidly deteriorated with the development of diabetic ketoacidosis (DKA), septic shock from Clostridium perfringens bacteremia, progressive acute kidney injury (AKI), and extensive cavitating lung destruction with BPF. Serial imaging showed worsening cavitation, suspicious for necrotic malignancy rather than superimposed infection. Bronchoalveolar lavage (BAL) grew invasive pulmonary aspergillosis (IPA). Surgical and endobronchial interventions were not viable due to extensive disease and critical illness. Despite aggressive antimicrobial and antifungal therapy, the patient developed massive hemoptysis leading to pulseless electrical activity (PEA) arrest and death. Conclusion: This case illustrates a lethal cascade of cavitating lung malignancy complicated by BPF, polymicrobial sepsis, and invasive. Early recognition of structural lung compromise and prompt multidisciplinary discussions, including goals of care, are essential in critically ill patients with advanced pulmonary malignancy.

Keywords: ***Lung adenocarcinoma; Bronchopleural fistula; Tension pneumothorax; Invasive aspergillosis; Critical illness; Pulmonary hemorrhage; Critical care; Acute kidney injury; Renal replacement therapy; Palliative care; Goal of care; Multifocal pneumonia***

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1. Introduction

Lung cancer is the leading cause of death from cancer in the U.S., accounting for about 20% of all cancer deaths, with approximately 226,650 newly diagnosed cases and 124,730 deaths expected in 2025 [1]. While non-small cell lung cancer (NSCLC) is the most common type of lung cancer, accounting for nine out of every 10 cases, adenocarcinoma of the lung is the most common form of NSCLC, accounting for 30% of all cases overall and about 40% of all NSCLC [2]. Lung adenocarcinoma remains the most common histologic subtype of non-small cell lung cancer (NSCLC among the young population who have never smoked, and women are more prone than men to develop this type of cancer, which is frequently associated with advanced-stage disease at diagnosis [3,4]. A significant portion of lung cancer patients are vulnerable to central airway respiratory complications due to tumor-related airway obstruction, parenchymal destruction, pleural involvement, and immunosuppression from malignancy or treatment. As many as 40% of lung cancer-related deaths are due to these complications [5].

Pneumothorax is the presence of air in the pleural space, which can be generally grouped as spontaneous or traumatic, and often occurs in patients with pulmonary cancer [6]. If pneumothorax is not associated with underlying lung disease and classified as primary, those related to underlying lung disease are classified as secondary [6]. Tension pneumothorax and BPF are related to severe pneumonia. They are rare but could be potentially fatal complications, such as acute respiratory distress syndrome (ARDS), AKI, cardiac injury, liver dysfunctions, lung cavitation, pleural effusion, and pericardial effusion in mechanically ventilated patients, especially those with underlying lung cancer, immunocompromised, and infections [7,8]. Additionally, IPA, traditionally associated with neutropenia, is increasingly recognized in critically ill non-neutropenic patients, particularly those receiving corticosteroids or prolonged mechanical ventilation [9,10].

This case illustrates a fatal convergence of advanced lung adenocarcinoma, persistent BPF, polymicrobial sepsis, DKA, IPA, and AKI, emphasizing the complexity of care and prognostic challenges in critically ill oncology patients.

2. Case Presentation

A 62-year-old man with a medical history significant for recently diagnosed lung adenocarcinoma (2 weeks prior), hypertension, type 2 diabetes mellitus, nicotine dependence, coronary artery bypass grafting (CABG), and prior left retinal detachment presented to the emergency department with acute shortness of breath. Initial studies on arrival in the emergency department (ED), he was in severe respiratory distress with a blood pressure of 205/110 mmHg, a heart rate of 150 beats/min, a respiratory rate of >40 breaths/min, and an oxygen saturation of the low 90s even on supplemental oxygen. Initial laboratory studies were significant for white blood cell (CBC) count of 34.4 $\times 10^9$/L, serum glucose of 353 mg/dL, hemoglobin A1c of 8.0%, lactate of 2.9 mmol/L, C-reactive protein of 112.6 mg/L, and B-type natriuretic peptide (BNP) of 203 pg/mL. Urinalysis was negative for infection; urine toxicology was positive for opioids. Initial arterial blood gas (ABG) showed pH 7.43, pCO_2 94.9 mmHg, HCO_3^- 23.1 mmol/L, and O_2 saturation 93.2%. Chest X-ray (CXR) demonstrated normal heart size, bilateral perihilar and lower lung interstitial and airspace opacities, which may reflect pulmonary edema and/or multifocal pneumonia; no pleural effusion. Point-of-care ultrasound (POCUS) demonstrated diffuse bilateral B-lines, and the chest radiograph showed pulmonary edema. He was placed on continuous positive airway pressure (CPAP).

Despite non-invasive ventilation, the patient developed worsening hypercapnic respiratory failure. Repeat ABG revealed pH 7.23, pCO_2 56.5 mmHg, pO_2 146 mmHg. He was transitioned to the intensive care unit (ICU) for intubation to protect his airway and for closer monitoring. Broad-spectrum empiric therapy antimicrobials were initiated.

Repeated CXR after intubation revealed a large right-sided tension pneumothorax from the right upper lung to the lower lung with bilateral interstitial opacities. Computed tomography (CT) chest revealed right pneumothorax (~10%), left lower lobe mass-like consolidation, pleural effusion, several large mediastinal lymph nodes consistent with metastatic disease, and a right apical mass with rib metastasis measuring approximately 6 cm. CT head and brain demonstrated no acute intracranial pathology; moderate chronic microangiopathy. CT Abdomen/Pelvis demonstrated lateral simple renal cysts without obstruction. A right-sided chest tube was placed, resulting in a persistent air leak for 3 days and approximately 700 mL of total drainage in the first 24 hours.

The patient developed DKA on hospital day 3 (glucose 565 mg/dL, beta-hydroxybutyrate 3.74 mmol/L), which resolved after low-rate insulin infusion. Sedation holidays failed to demonstrate meaningful neurological recovery. Blood cultures grew Clostridium perfringens, prompting antimicrobial escalation to meropenem and later metronidazole plus ampicillin-sulbactam. AKI progressed with rising BUN and creatinine levels accompanied by hypernatremia and hyperkalemia.

On the 11th day of the hospital course, bronchoalveolar lavage (BAL) wash grew Aspergillus (index 5.82), and the endotracheal tube also grew yeast. Voriconazole renally dosing was initiated. On the 13th day of the hospital course, the patient developed massive hemoptysis, expelled blood clots via the endotracheal tube, and suffered pulseless electrical activity (PEA) arrest. Despite prolonged advanced cardiovascular life support (ACLS) resuscitation, his family transitioned him to comfort measures, and the patient expired.

3. Discussion

This case demonstrates a relatively rare but devastating cascade of pulmonary and systemic complications in advanced lung cancer. Malignancy-related parenchymal destruction predisposed the patient to pneumothorax and BPF, which are associated with high mortality in mechanically ventilated patients [11]. BPF is an improper contact between the bronchial trunk or a segmental bronchus and the pleural cavity due to many potential causes, which is a potentially fatal complication most often caused after pneumonectomy, often caused by pulmonary infection and respiratory failure [12-14]. The most common cause is post-pneumonectomy, estimated to be 4.5-20% after total pneumonectomy and 0.5-1% after lobectomy [11,15]. Other causes include necrotizing infections, tuberculosis, pneumonia, empyema, chemotherapy or radiation therapy, and thoracic trauma [14,15]. When the pleural cavity comes into contact with the outside environment, as air partially enters the pleural cavity, the amount of effective air exchange is reduced, leading to inadequate ventilation and blood perfusion, and inevitably to hypoxia and respiratory failure [16]. Patients with pulmonary malignancy usually have fistulas due to infiltration of the tumor growth in the stump or chronic ischemia, which will often experience pneumothorax, frequently accompanied by severe infection and decreased immunity [17].

Therefore, BPF required urgent intervention to achieve better outcomes, which require accurate location and timely closure of the fistula. Thoracic drainage is the first step, followed by prophylactic antibiotics and a variety of blocking agents that induce

and stimulate granulation tissue formation, leading to cell proliferation and fistula closure [18-20]. Airway stenting is more widely used in malignant cases, as it provides immediate symptomatic relief and improves quality of life. Silicone stents are used in patients with external compressional stenosis of the central airway, while metal stents are placed in the trachea for bronchial obstruction [21]. Other methods include endobronchial valves, such as the Zephyr endobronchial valve and intrabronchial valve, for bronchoscopic lung decompression procedures, and the endobronchial Watanabe spigot, placed into the target bronchus to prevent air from entering the diseased bronchus [23-25].

In addition, a pneumothorax during mechanical ventilation, complicated by a persistent air leak, is considered a serious complication of ventilator therapy, as it limits lung re-expansion, increases infection risk, and complicates ventilatory management [26]. Viral and bacterial pneumonia and IPA are increasingly recognized in non-neutropenic ICU patients or patients with malignancies, but their incidence is also increasing in non-immunocompromised individuals [27,28]. However, BPF associated with IPA in ICU admissions is associated with a higher risk of mortality exceeding 50%, which emphasizes that severe presentation of illness should require more aggressive management strategies and closer monitoring of organ function [29]. Clostridium perfringens bacteremia, although uncommon, is associated with fulminant sepsis and high fatality rates, predominantly affecting individuals with cancer and in immunocompromised states, along with bronchial pulmonary complications [30,31].

Pulmonary complications combined with septic shock, DKA, renal failure, and progressive malignancy could significantly worsen the prognosis of oncology patients, especially among ICU-admitted patients. AKI is among the common complications of patients with cancer, as it has a profound influence on prognosis and survival outcome [32,33]. AKI has been suggested to be a significant prognostic factor for short-term mortality of ICU-admitted patients with lung cancer [34]. Various factors during the ICU course could cause AKI, including ICU treatment choices, anti-infection regimen, level of blood lactate, hydration, sepsis, and timing of onset [35]. From a mechanistic perspective, AKI also increases the risks of other adverse outcomes, including stroke, cardiovascular disease, and upper gastrointestinal hemorrhage [36]. These results further suggested that AKI evaluation and management are essential strategies in the ICU admission and management of patients with lung cancer due to their high mortality risks.

This case underscores the importance of early multidisciplinary involvement, aggressive reassessment of prognosis, and timely goals-of-care discussions in patients with advanced malignancy and refractory critical illness.

4. Conclusion

Advanced lung adenocarcinoma can predispose patients to catastrophic pulmonary complications, including but not limited to tension pneumothorax, BPF, invasive fungal infection, DKA, and AKI. This case highlights the lethal synergy of structural lung disease, polymicrobial sepsis, and critical illness in the setting of advanced adenocarcinoma of the lung. Early recognition, realistic prognostication, and proactive palliative engagement are essential in guiding care for high-risk oncology patients.

5. Contributors

The authors wrote and edited the manuscript. The authors approved the final version of the manuscript and are responsible for all aspects of this study.

6. Competing Interests

None stated

7. Funding

None

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