Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

The Role of Bronchoscopy in Acute Lung Atelectasis Due to Airway Mucus Plugging: A Case report

I Bona Marasi Manik

jamesbonz10@gmail.com

University of Mataram

Gemilang Khusnurrokhman

University of Mataram

Eko Widya Nugroho

Case Report

Keywords: Acute lung atelectasis, Airway mucus plugging, Flexible bronchoscopy, Bronchial toilet

Posted Date: September 28th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11148843/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations:
No competing interests reported.

Participant Consent to Publish: Written informed consent was obtained from the patient's legal guardian for participation and publication of this case report and any accompanying images. A copy of the written informed consent is available for review by the editorial office upon reasonable request.

The Role of Bronchoscopy in Acute Lung Atelectasis Due to Airway Mucus Plugging: A Case report

I Bona Marasi Manik[1], Gemilang Khusnurrokhman[2], Eko Widya Nugroho[3]

[1]Department of Pulmonology and Respiratory Medicine, Faculty of Medicine, Universitas Mataram, Mataram, Indonesia
[2]Department of Pulmonology and Respiratory Medicine, Faculty of Medicine, Universitas Mataram, Mataram, Indonesia
[3]Department of Emergency and Traumatology, West Nusa Tenggara Provincial Regional General Hospital

Abstract

Background: Acute lung atelectasis caused by airway mucus plugging is a potentially reversible cause of respiratory failure, particularly in postoperative and critically ill patients. Prompt recognition and timely intervention are essential to prevent prolonged hypoxemia, mechanical ventilation, and other serious complications. Flexible bronchoscopy is considered the gold standard for diagnosing and treating obstructive atelectasis by directly identifying and removing airway obstruction.

Case Presentation: A 32-year-old man developed severe hypoxemia and complete right lung atelectasis on the second day following exploratory laparotomy for abdominal trauma. Despite chest tube insertion, invasive mechanical ventilation, and supportive management, oxygenation remained critically impaired. Bedside lung ultrasonography demonstrated extensive right lung collapse. Therapeutic flexible bronchoscopy revealed complete obstruction of the right upper lobe bronchus by a thick mucus plug, with additional retained secretions in the right bronchial tree. Bronchial toilet and suctioning successfully restored airway patency. Immediate post-procedure chest radiography demonstrated significant right lung re-expansion, while arterial oxygenation improved markedly, with PaO_2 increasing from 40 mmHg to 194 mmHg. The patient was subsequently weaned from mechanical ventilation, experienced progressive clinical recovery, and was discharged from the intensive care unit in stable condition.

Conclusion: This case highlights that mucus plug-induced atelectasis should be considered in postoperative patients presenting with sudden hypoxemia and radiographic evidence of lung collapse. Early therapeutic flexible bronchoscopy provides both definitive diagnosis and effective treatment by restoring airway patency, promoting rapid lung re-expansion, improving oxygenation, facilitating ventilator weaning, and optimizing clinical outcomes when conservative management is unsuccessful.

Keywords:Acute lung atelectasis, Airway mucus plugging, Flexible bronchoscopy, Bronchial toilet

Introduction

Atelectasis is a frequent pulmonary complication among critically ill and postoperative patients, particularly after major abdominal or thoracic surgery. The condition results from alveolar collapse due to airway obstruction, external compression, or surfactant dysfunction, leading to impaired alveolar ventilation, ventilation–perfusion mismatch, intrapulmonary shunting, and hypoxemia. Failure to recognize and treat atelectasis promptly may result in acute respiratory failure, prolonged mechanical ventilation, extended intensive care unit (ICU) stay, and increased morbidity and mortality. [1-5]

Among the reversible causes of atelectasis, airway obstruction by mucus plugs is especially important because timely intervention can rapidly restore lung function. In critically ill patients, mucus plug formation is promoted by excessive secretion production, impaired mucociliary clearance following endotracheal intubation, suppression of the cough reflex due to sedation, postoperative pain, prolonged immobilization, and mechanical ventilation. Complete bronchial obstruction may cause abrupt lobar or total lung collapse, manifested clinically by severe hypoxemia, reduced breath sounds, and radiographic signs of ipsilateral volume loss, including rib crowding, mediastinal shift toward the affected side, and increased hemithoracic opacity. [1-3]

Flexible bronchoscopy is regarded as the gold-standard procedure for diagnosing and managing obstructive atelectasis. Beyond identifying the exact site and cause of airway obstruction, it enables immediate therapeutic airway clearance through bronchial toilet and mucus plug extraction. Recent evidence suggests that early therapeutic bronchoscopy facilitates rapid lung re-expansion, improves oxygenation, shortens the duration of mechanical ventilation, and accelerates clinical recovery, particularly in patients who fail to respond to conservative therapies such as chest physiotherapy and endotracheal suctioning. This report describes a case of acute right lung atelectasis caused by airway mucus plugging that was successfully managed with therapeutic flexible bronchoscopy, highlighting its critical role in the early management of postoperative respiratory deterioration. [9-12]

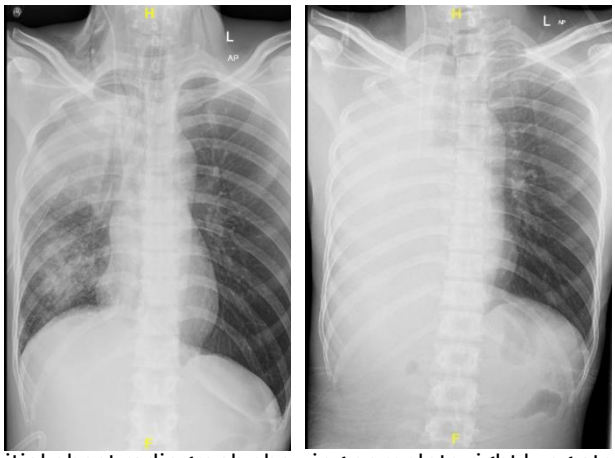

Figure 1. Initial chest radiograph showing complete right lung atelectasis with ipsilateral mediastinal shift.

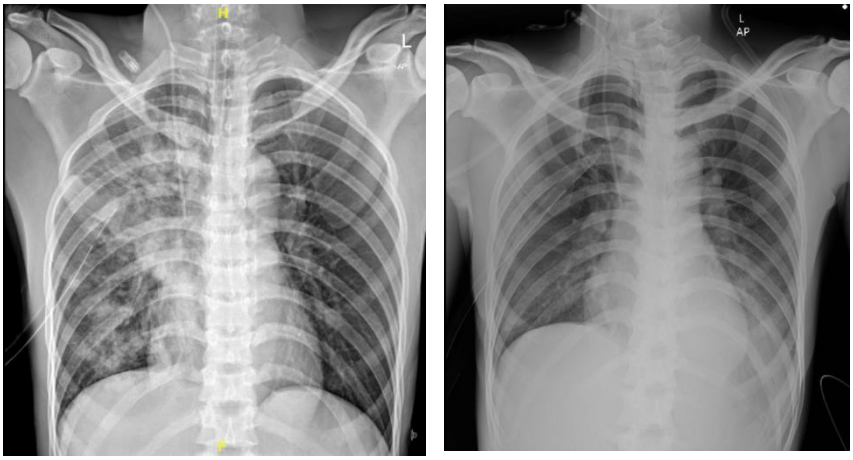

Figure 2. Follow-up chest radiograph after therapeutic flexible bronchoscopy demonstrating significant re-expansion of the right lung and improvement of atelectasis.

Figure 3. Bedside lung ultrasonography demonstrating the curtain sign, compressive atelectasis, lung consolidation, and hepatization of the right lung, with minimal right pleural effusion.

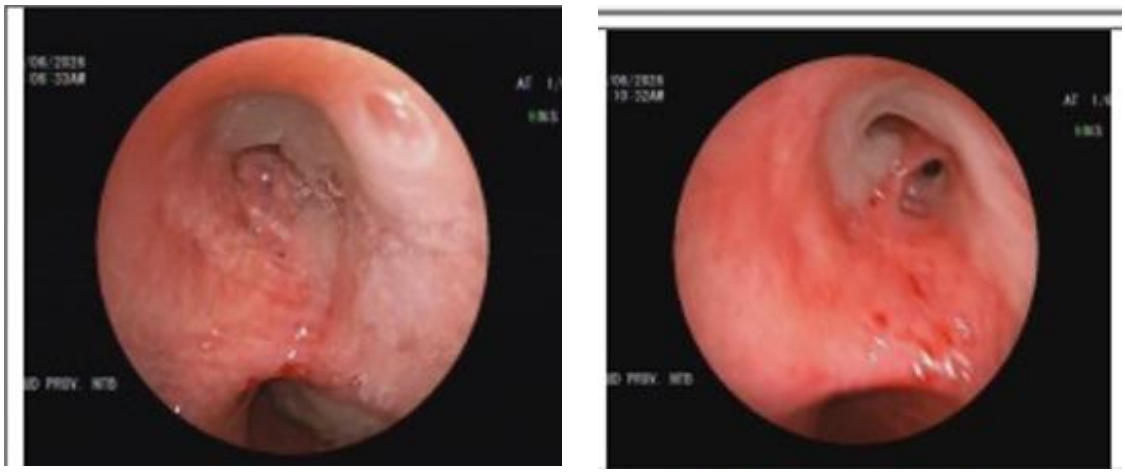

Figure 4. Flexible bronchoscopic view demonstrating a thick mucus plug obstructing the right upper lobe bronchus before bronchial toilet.

Case Presentation

A 32-year-old man was admitted to the emergency department following a motor vehicle accident with a laceration over the right side of the abdomen. On admission, he was fully conscious and denied dyspnea, cough, or fever. Physical examination revealed a 6 × 6 cm laceration on the right abdominal wall without active bleeding. The patient subsequently underwent emergency exploratory laparotomy, anterior abdominal wall reconstruction, and surgical debridement.

On the second postoperative day, the patient's clinical condition deteriorated with a decreased level of consciousness and severe hypoxemia, with an oxygen saturation of 66% despite receiving 15 L/min of oxygen via a non-rebreather mask. Chest radiography demonstrated complete right lung atelectasis with ipsilateral rib crowding, rightward tracheal deviation, and compensatory hyperinflation of the left lung (Figure 1). Arterial blood gas analysis revealed severe hypoxemia (PaO_2 28 mmHg) with preserved acid–base balance.

A right-sided chest tube was inserted, and the patient was transferred to the intensive care unit (ICU), where invasive mechanical ventilation was initiated in synchronized intermittent mandatory ventilation (SIMV) mode with an FiO_2 of 100%, positive end-expiratory pressure (PEEP) of 5 cmH_2O, pressure support of 7 cmH_2O, tidal volume of 380 mL, inspiratory-to-expiratory ratio of 1:2, and a respiratory rate of 16 breaths/min. Despite these interventions, arterial blood gas analysis after intubation continued to show severe hypoxemia (PaO_2 40 mmHg).

A pulmonology consultation was obtained, and be dside lung ultrasound revealed a curtain sign, compression atelectasis, lung consolidation with hepatization, and minimal right pleural effusion, findings consistent with extensive right lung collapse.

Given the persistent hypoxemia despite mechanical ventilation and supportive therapy, therapeutic flexible fiberoptic bronchoscopy was performed.

Bronchoscopic examination demonstrated a large mucus plug completely obstructing the right upper lobe bronchus, accompanied by bronchial mucosal inflammation. Thick yellow tenacious secretions completely occluded the bronchial lumen. Bronchial suctioning and bronchial toilet were performed until the bronchial orifice was fully patent, revealing hyperemic bronchial mucosa. Additional thick purulent secretions with diffuse mucosal hyperemia were observed in the bronchus intermedius, right middle lobe bronchus, and right lower lobe bronchus. All retained secretions were successfully removed by repeated suctioning and bronchial toilet (Figure 3).

A follow-up chest radiograph obtained immediately after bronchoscopy demonstrated significant re-expansion of the right lung with marked resolution of the atelectasis (Figure 2). Arterial oxygenation improved dramatically, with PaO_2 increasing from 40 mmHg before bronchoscopy to 194 mmHg after the procedure. Consequently, ventilatory support was gradually reduced, and the patient was transitioned to continuous positive airway pressure (CPAP) mode with an FiO_2 of 60%, PEEP of 5 cmH_2O, and pressure support of 12 cmH_2O.

By the fourth postoperative day, the patient's respiratory status had improved substantially, with an oxygen saturation of 98% while receiving 6 L/min of oxygen via a simple face mask. On postoperative day eight, oxygen supplementation was further reduced to a nasal cannula, and the patient was transferred from the intensive care unit to the general ward in stable condition.

Discussion

Atelectasis is the partial or complete collapse of the alveoli, resulting in reduced lung volume and loss of the alveoli's ability to participate in gas exchange. This condition may occur due to airway obstruction (obstructive or resorptive atelectasis), external compression of the lung, surfactant dysfunction, or contraction of the lung parenchyma secondary to fibrosis. Reduced alveolar aeration leads to decreased regional ventilation, resulting in ventilation–perfusion (V/Q) mismatch and increased intrapulmonary shunting, ultimately causing hypoxemia. [1-3]

The present case illustrates acute right lung atelectasis caused by bronchial obstruction due to a mucus plug in a patient following exploratory laparotomy for abdominal trauma. Clinical deterioration occurred on the second postoperative day, characterized by decreased consciousness, profound hypoxemia (PaO_2 28 mmHg), and an oxygen saturation of only 66% despite high-flow oxygen therapy. Chest radiography demonstrated complete right hemithoracic opacity accompanied by ipsilateral rib

crowding and tracheal deviation toward the affected side, findings consistent with significant loss of lung volume secondary to atelectasis. Initial management, including mechanical ventilation and chest tube insertion, failed to improve oxygenation. Flexible bronchoscopy subsequently identified and removed a mucus plug completely obstructing the right upper lobe bronchus, resulting in immediate lung re-expansion and a marked increase in arterial oxygenation, with PaO_2 improving to 194 mmHg. These findings strongly suggest that mechanical airway obstruction was the primary cause of respiratory failure in this patient. [4-6,9-12]

Mucus plug formation in this case was likely multifactorial. Endotracheal intubation and mechanical ventilation are known to impair mucociliary clearance, induce airway mucosal injury, and stimulate excessive mucus production through local inflammatory responses. Furthermore, postoperative pain following laparotomy limited effective coughing, thereby impairing secretion clearance. Prolonged immobilization during intensive care further promoted mucus retention and subsequent bronchial obstruction. Similar mechanisms have been described by Athish et al., who reported retained airway secretions as a major cause of acute postoperative atelectasis due to mucus plugging among critically ill surgical patients. [7-10]

From a pathophysiological perspective, complete bronchial obstruction leads to progressive absorption of trapped alveolar gas into the pulmonary circulation, resulting in resorption atelectasis. Continued perfusion of non-ventilated alveoli produces an intrapulmonary shunt, allowing deoxygenated blood to bypass gas exchange. This mechanism explains the persistence of severe hypoxemia despite administration of high inspired oxygen concentrations during mechanical ventilation. In addition, alveolar collapse decreases lung compliance, increases the work of breathing, and exacerbates ventilation–perfusion mismatch. [1-3,17]

Bedside lung ultrasound (LUS) in this patient demonstrated consolidation with hepatization and compression atelectasis, findings consistent with severe loss of lung aeration. LUS has become an increasingly valuable bedside imaging modality in intensive care settings because of its superior sensitivity compared with portable chest radiography for detecting atelectasis, while avoiding radiation exposure and allowing serial assessment. However, although LUS accurately identifies lung collapse, it cannot directly determine the underlying cause of endobronchial obstruction. Therefore, flexible bronchoscopy remains the definitive diagnostic modality when mucus plugging is suspected. [13-15]

Bronchoscopic examination revealed thick mucoid secretions obstructing the lumen of the right upper lobe bronchus, with additional secretions present in the bronchus intermedius as well as the middle and lower lobe bronchi. Immediate evacuation of the secretions by suction and bronchial toilet successfully restored airway patency, resulting in a marked improvement in right lung ventilation. The increase in PaO_2

from 40 mmHg after endotracheal intubation to 194 mmHg following bronchoscopy indicates that the patient's hypoxemia was primarily caused by mechanical airway obstruction rather than impaired diffusion or a primary perfusion abnormality. [9-12]

These findings are consistent with the case series reported by Athish et al. (2024), in which postoperative patients with mucus plug-induced atelectasis experienced rapid improvement in oxygenation and lung re-expansion following therapeutic bronchoscopy. Their study also suggested that combining bronchoscopy with chest physiotherapy, postural drainage, early mobilization, and pulmonary rehabilitation reduces recurrent atelectasis and facilitates successful ventilator weaning. [10]

In the present case, early bronchoscopy represented the most appropriate therapeutic strategy. Conventional endotracheal suctioning is generally limited to proximal airway secretions and is often ineffective for mucus plugs located within lobar or segmental bronchi. Direct bronchoscopic visualization allows accurate identification of the obstructing lesion and immediate therapeutic removal, making bronchoscopy the preferred intervention in patients with persistent hypoxemia accompanied by radiographic evidence of significant lung volume loss. [9-12,19]

Radiological improvement immediately following bronchoscopy further supports the effectiveness of this intervention. Rapid re-expansion of the right lung was accompanied by successful ventilator weaning, progressive reduction in oxygen requirements, and complete clinical recovery. Early recognition and prompt bronchoscopic intervention may also reduce the risk of secondary complications, including ventilator-associated pneumonia, prolonged respiratory failure, and acute respiratory distress syndrome (ARDS). [5-8,17-18]

Although flexible bronchoscopy is an invasive procedure, its complication rate remains low when performed by experienced operators with appropriate respiratory and hemodynamic monitoring. Potential adverse events—including transient desaturation, bronchospasm, cardiac arrhythmias, and minor bleeding—are generally manageable and are outweighed by the substantial clinical benefits in patients with suspected bronchial obstruction caused by mucus plugging. [9,11,12,19]

Overall, this case emphasizes that mucus plugging should always be considered in postoperative patients presenting with sudden hypoxemia and radiographic evidence of acute lung volume loss. An integrated diagnostic approach combining clinical evaluation, chest radiography, lung ultrasound, and flexible bronchoscopy facilitates early diagnosis and targeted management. The excellent clinical response observed in this patient further supports the growing evidence that therapeutic bronchoscopy is a safe and highly effective intervention for restoring airway patency, improving oxygenation, accelerating lung re-expansion, and optimizing clinical outcomes in patients with mucus plug-induced obstructive atelectasis. [9-15,19-20]

Conclusion

Acute lung atelectasis caused by mucus plugging represents a reversible cause of respiratory failure that should be considered in postoperative patients presenting with sudden hypoxemia and radiographic evidence of lung volume loss. This case demonstrates that flexible bronchoscopy serves not only as a definitive diagnostic modality for identifying endobronchial obstruction but also as an effective therapeutic intervention through bronchial toilet and direct removal of retained secretions. Early bronchoscopic management resulted in rapid lung re-expansion, significant improvement in oxygenation, successful ventilator weaning, and favorable clinical recovery.

An integrated approach combining clinical assessment, chest radiography, lung ultrasound, and flexible bronchoscopy enables timely diagnosis and targeted treatment. This case adds to the growing body of evidence supporting early therapeutic bronchoscopy as a safe and effective strategy for managing mucus plug-induced obstructive atelectasis, particularly in patients who fail to respond adequately to conservative therapy. Although further prospective studies are needed to strengthen the current evidence, early bronchoscopic intervention should be strongly considered in selected postoperative patients with persistent hypoxemia and suspected airway obstruction.

Reference

Hedenstierna G, Rothen HU. Atelectasis formation during anesthesia: causes and measures to prevent it. J Clin Monit Comput. 2023;37(2):241-51.

Duggan M, Kavanagh BP. Pulmonary atelectasis: pathophysiology and perioperative implications. Anesthesiology. 2021;134(5):821-35.

Lumb AB. Nunn's applied respiratory physiology. 10th ed. Philadelphia: Elsevier; 2024.

Miskovic A, Lumb AB. Postoperative pulmonary complications. Br J Anaesth. 2022;129(3):319-34.

Fernandez-Bustamante A, et al. Postoperative pulmonary complications: early diagnosis and prevention. Chest. 2023;164(2):518-34.

Canet J, Gallart L. Postoperative pulmonary complications: current concepts. Eur Respir Rev. 2022;31:220013.

Papazian L, et al. Formal guidelines: management of acute respiratory failure in critically ill adults. Intensive Care Med. 2023;49:1-25.

Torres A, et al. ERS clinical practice guidelines for hospital-acquired pneumonia. Eur Respir J. 2023;61:2201471.

Wahidi MM, et al. Technical aspects of flexible bronchoscopy. Chest. 2020;158(3):1269-88.

Athish TS, et al. The role of bronchoscopy and chest physiotherapy in postoperative acute lung atelectasis caused by airway mucus plugging. Cureus. 2024;16:e62536.

Du Rand IA, et al. British Thoracic Society guideline for diagnostic flexible bronchoscopy in adults. Thorax. 2022.

Ernst A, Herth FJF. Principles and practice of interventional pulmonology. Cham: Springer; 2023.

Volpicelli G, et al. International evidence-based recommendations for point-of-care lung ultrasound. Intensive Care Med. 2021;47:1217-38.

Soldati G, et al. Lung ultrasound in critically ill patients. Respiration. 2022;101:97-113.

Mojoli F, et al. Lung ultrasound for critically ill patients. Intensive Care Med. 2021;47:700-14.

Broaddus VC, Mason RJ, Ernst JD, et al. Murray & Nadel's textbook of respiratory medicine. 7th ed. Philadelphia: Elsevier; 2022.

Brochard L, Slutsky A, Pesenti A. Mechanical ventilation to minimize lung injury. N Engl J Med. 2023;389:1235-46.

Fan E, et al. Acute respiratory distress syndrome: advances in diagnosis and management. Lancet. 2023;401:1949-63.

American Thoracic Society. Adult bronchoscopy competency and quality indicators. Am J Respir Crit Care Med. 2022;206:e1-e25.

European Respiratory Society. ERS handbook of respiratory intensive care. 3rd ed. Lausanne: European Respiratory Society; 2024.