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Case report

THE ROLE OF BRONCHOSCOPY IN INTENSIVE CARE MEDICINE, CASE REPORT

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ABSTRACT

Purpose. Airway maintenance, adequate ventilation, and pulmonary gas exchange are crucial for critically ill patients. The challenges of performing in intensive care patients often differ significantly from routine surgical procedures in the operating room. The aim of our study was to assess the effectiveness of bronchoscopic aspiration in improving respiratory function in a patient on prolonged artificial ventilation.

Material/Methods. A 69-year-old male was admitted to the ICU six days after an open cystoprostatectomy, presenting with respiratory failure. Initial treatment included blind airway suctioning, nebulization, chest physiotherapy, and empirical antibiotics. Due to persistent atelectasis and respiratory failure, bronchoscopic aspiration was performed. A total of nine bronchoscopies with bronchoalveolar lavage (BAL) were conducted for aspiration and microbiological testing, guiding adjustments in antibiotic therapy. After 61 days in the ICU, the patient was transferred to the Department of Urology and later discharged.

Results. Bronchoscopic aspiration significantly improved the patient's condition, with noticeable improvements after the first bronchoalveolar lavage (BAL). Pulmonary imaging on X-ray and blood oxygenation showed clear progress, with better lung function and enhanced ventilation parameters. These changes allowed for a reduction in oxygen concentration and improved gas exchange. After 61 days in the ICU, the patient was successfully transferred to the Department of Urology and later discharged in stable condition.

Conclusions. Bronchoscopic aspiration is a highly effective method for improving ventilation and oxygenation in patients on prolonged mechanical ventilation. It plays a crucial role in managing airway obstructions atelectasis, and enhancing microbiological diagnostics.

Keywords: airway maintenance, atelectasis, respiratory impairment, bronchoscopy,

INTRODUCTION

Airway maintenance, adequate ventilation, and pulmonary gas exchange are crucial for critically ill patients. The challenges of performing in intensive care patients often differ significantly from routine surgical procedures in the operating room. This also implies the need for a high level of competence regarding the rapidly developing advances in airway management [1]. Multiple factors can cause respiratory impairment in critically ill patients. Some of the most common are atelectasis. The development of atelectasis can be the result of numerous causes – reduced mucociliary clearance, reduced cough efficiency, increased production of secretions in the respiratory tract, increased sputum viscosity, or a combination of these factors. In critically ill patients, mechanical ventilation might cause hospital-acquired pneumonia (HAP) and Ventilator-associated pneumonia (VAP), both conditions promote atelectasis and stagnant secretions that may worsen oxygenation and delay weaning from he ventilator [2, 3]. Nowadays, treatment of atelectasis in intensive care unit (ICU) patients has been focused on blind airway suctioning, bronchoscopy with or without nebulization, and chest physiotherapy. Bronchoscopy is regarded as an attractive method for endobronchial mucus clearing, which may result in a more effective airway clearance as it is performed under direct visualization of the airways.

The German laryngologist Gustav Killian is attributed with performing the first bronchoscopy in 1897. Killian used a rigid bronchoscope to remove a pork bone from a main bronchus. The procedure was performed on an awake patient with cocaine administered as a local anesthetic. From that point until the 1970s, extremely rigid bronchoscopes were used. In 1967 Shigeto Ikeda introduced the flexible bronchoscope (FB), which was a revolution in the field of respiratory endoscopy. This was followed by the invention of video bronchoscopes in the 1980s, which turned them into an essential tool in the diagnosis and treatment of various lung diseases [4]. In the 21st century, bronchoscopy continues to evolve with the introduction of electromagnetic navigation bronchoscopy (ENB), radial endobronchial ultrasound (EBUS) and even

robotically assisted bronchoscopy, which is gaining momentum following FDA approval in 2018 [5].

INDICATIONS

The common indications for FB in the ICU are the visualization of the trachea and main bronchi, restoring airway patency mainly as removing abundant secretions (especially in patients with artificial devices - invasive and non-invasive), managing hemoptysis and diagnostic sampling.

Infection:

In the ICU, FB with broncho alveolar lavage (BAL) in community-acquired pneumonia is used when antibiotic therapy fails or to investigate potential alternative diagnoses in intubated or non-intubated patients. A clinical context where FB appears particularly useful is immunocompromised patients, such as transplant recipients, those with hematologic malignancies, active cancer and receiving immunosuppressive therapy. The identification of infectious agent leads to ongoing treatments being modified in a relatively high percentage of patients, especially when pulmonary infiltrates are present [6]. According to recent guidelines, in cases of suspected pulmonary invasive aspergillosis, BAL galactomannan measurement is strongly recommended [7]. BAL is particularly considered the gold standard for diagnosis of Pneumocystis jirovecii, showing a sensitivity of 90%-98% in the absence of previous antibiotic use for treatment or prophylaxis [6].

Airway inspection and management of obstructions:

The role of FB in the ICU is essential for visualizing airway systems and obstructions and restoring patency in different circumstances, such as atelectasis, lobar collapse due to mucoid plugs, or inhalation injuries. Patients with artificial devices, such as tracheostomy cannula, frequently develop airway obstructions due to mucus plugs, secretions or clots. Bronchoscopic management of these cases includes the removal of endobronchial material by means of suction or forceps. The overall success rate for the correction of acute atelectasis caused by airway obstruction due to mucus plugs is more than 70% in various reports. Moreover, FB can be performed to evaluate tracheomalacia or tracheal stenosis after tracheostomy. Aspiration of gastric contents can be an indication for FB with lavage in critical care patients. FB can be useful for the visualization of the airways in case of thoracic trauma and suspected bronchial injury [8].

Sampling procedures:

BAL is a safe and minimally invasive bronchoscopic sampling method indicated for several lung diseases (e.g., immune-mediated, inflammatory, and infectious diseases). It can provide specimens for cytological and microbiological exams. Due to its excellent safety profile, BAL can be performed in critically ill patients while carefully monitoring vital parameters. A complete airway inspection should precede BAL execution, which, in turn, should precede any biopsies. 60-180 mL of room temperature sterile saline is used, divided into 3-4 fractions, and introduced through the suction channel of the bronchoscope. It is then withdrawn by suction, aiming to retrieve as much fluid as possible without causing airway collapse. The BAL fluid is subsequently stained and cultured for pathogens [8].

Other methods for diagnosis could be bronchial washing (BW) and endobroncheal biopsy, which are recommended for the diagnosis of visible endobronchial lesions [9].

Hemoptysis:

Hemoptysis is a challenging symptom associated with potentially life-threatening medical conditions. FB plays a relevant role in this context, helping to diagnose the etiology, localize the site, and identify the source of the bleeding, which is essential for successful clinical management. Moreover, it allows for the removal of clots, stopping active bleeding in certain cases (by means of bronchial blocker placement), and guiding angiographic embolization. In massive hemoptysis, flexible FB can be unable to remove enough blood. In life-threatening hemoptysis, airways patency should be immediately preserved; in this context, rigid bronchoscopy (RB) or tracheal intubation under general anesthesia are better options in comparison with FB. Moreover, during RB, a Fogarty catheter or other bronchial blockers may be placed in order to stop active bleeding. Alternatively, in cases of massive hemoptysis, FB can be useful for selective main bronchial intubation to assure safe ventilation of non-bleeding site [10].

COMPLICATIONS

Overall, data from the literature on FB safety in an ICU setting reported a reassuring profile, with a complication and mortality rate of 1.1% and 0.02%, respectively [8]. In this context, a standardized protocol for FB execution in IMCU patients is highly recommended to guide the decision-making process regarding indications and timing, estimate individualized risks, and arrange proper interventions in advance.

Hypoxemia:

Transient hypoxemia is the most common adverse event, being the result of a combination of alveolar collapse and depletion of intra-alveolar oxygen due to frequent suctioning and massive washing of the alveoli during BAL. Conversely, hypercapnia is usually the expression of hypoventilation caused by airway obstruction. Since most patients admitted to ICUs with acute respiratory failure are on oxygen supplementation or NIV, escalation in ventilatory support is one of the most common concern in the decision-making process, but in experienced hands and with adequate precautions, FB still has an acceptable safety profile in this context [11].

Bleeding:

Although patients admitted to ICUs usually present a baseline high risk of hemorrhage due to concomitant

comorbidities and medications (antiplatelets, anticoagulants, chemotherapy), the post-bronchoscopy bleeding rate is relatively low: 0.12% for FB with BAL and 3%-5% for TBLB or EBUS-TBNA [8]. To reduce the likelihood of this potential complication, it is crucial to optimize platelet count, prothrombin time and thromboplastin time values before FB and to effectively manage any drug that might influence coagulation parameters (warfarin, direct anticoagulants, antiplatelets agents).

Pneumothorax:

Pneumothorax rarely occurs during FB (0.1%) or TBLB (0.4%). Even though pneumothorax mostly happens within a few minutes after the procedure, in a substantial minority of cases (approximately 40%), it can be delayed, requiring careful monitoring of clinical parameters, particularly in patients under NIV. In this context, in addition to a chest X-ray, a bedside lung ultrasound may be helpful for detecting pneumothorax with an extremely high diagnostic accuracy [12].

Others:

Hypoxemia occurring during FB may cause an increase in cardiac workload, with elevations of heart rate (approximately 40% above baseline), blood pressure (a rise of 30% above baseline) and cardiac index (approximately 17%-32% above baseline). Despite this, major arrhythmias, as well as myocardial infarction, are rare events during FB.

Iatrogenic trauma to airways and bronchospasm have also been occasionally reported, whereas the onset of fever is relatively common, particularly after BAL (13%) or bronchial washing [8].

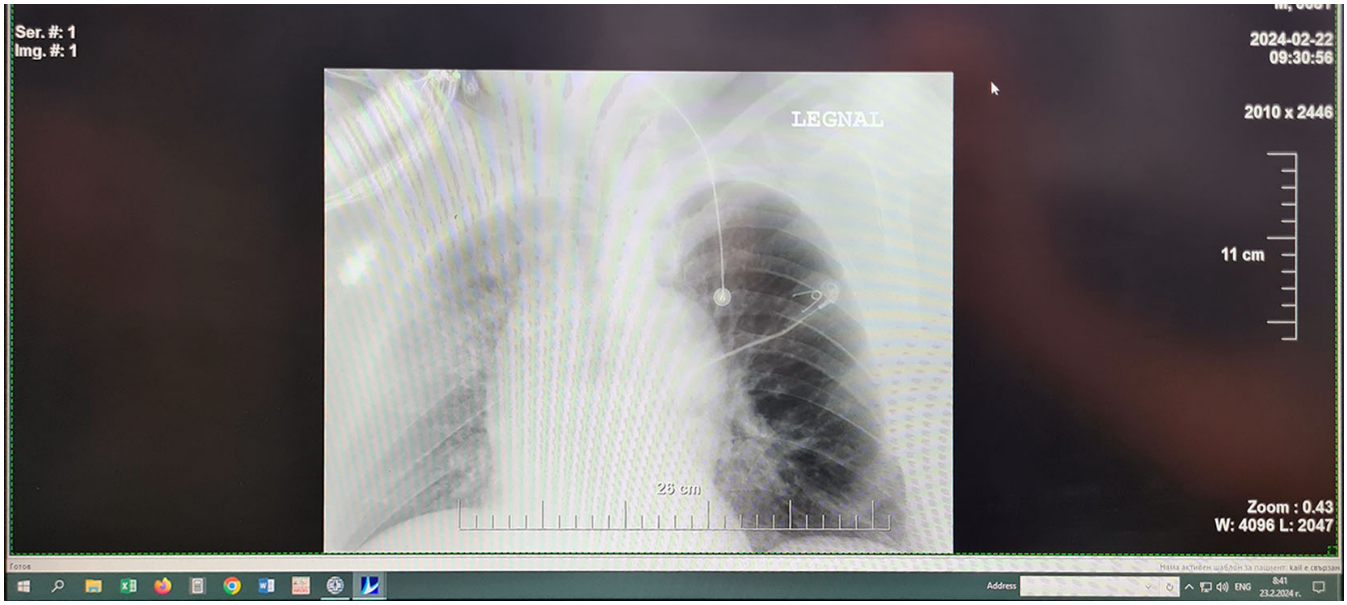
CASE REPORT

A 69-year-old male presented at the ICU in University Hospital St. Marina – Varna, six days after cystoprostatectomy with ureterocutaneostomy – open surgery. Complaining of progressive shortness of breath and signs of respiratory failure. Preoperative comorbidity was high blood pressure, atrial fibrillation and obesity. The surgical intervention was performed under general inhalation anesthesia, with no evidence of intraoperative complications and the patient was moved to the Department of Urology in the same hospital for postoperative care. Delayed ambulation has been reported in the early postoperative period due to associated obesity and patient noncooperation. Gradually progressive shortness of breath is an indication for admission to the intensive care unit and subsequent endotracheal intubation and mechanical ventilation. CT image showed atelectasis in the right lung base and early infiltrative changes. Treatment of atelectasis in the ICU has been focused on blind airway suctioning, nebulization, and chest physiotherapy. Empiric antibiotic treatment with Tazocin was also added to therapy. Four days after mechanical ventilation, we decided to extubate the patient and continue subsequent oxygen therapy with a face mask. Due to evidence from the blind aspiration microbiology for Pseudomonas aeruginosa and Klebsiella pneumoniae, the antibiotic therapy was changed to Meropenem and Metronidazole.

Seven days after extubation, despite active rehabilitation and respiratory physiotherapy, endotracheal intubation and mechanical ventilation were required again due to respiratory failure.

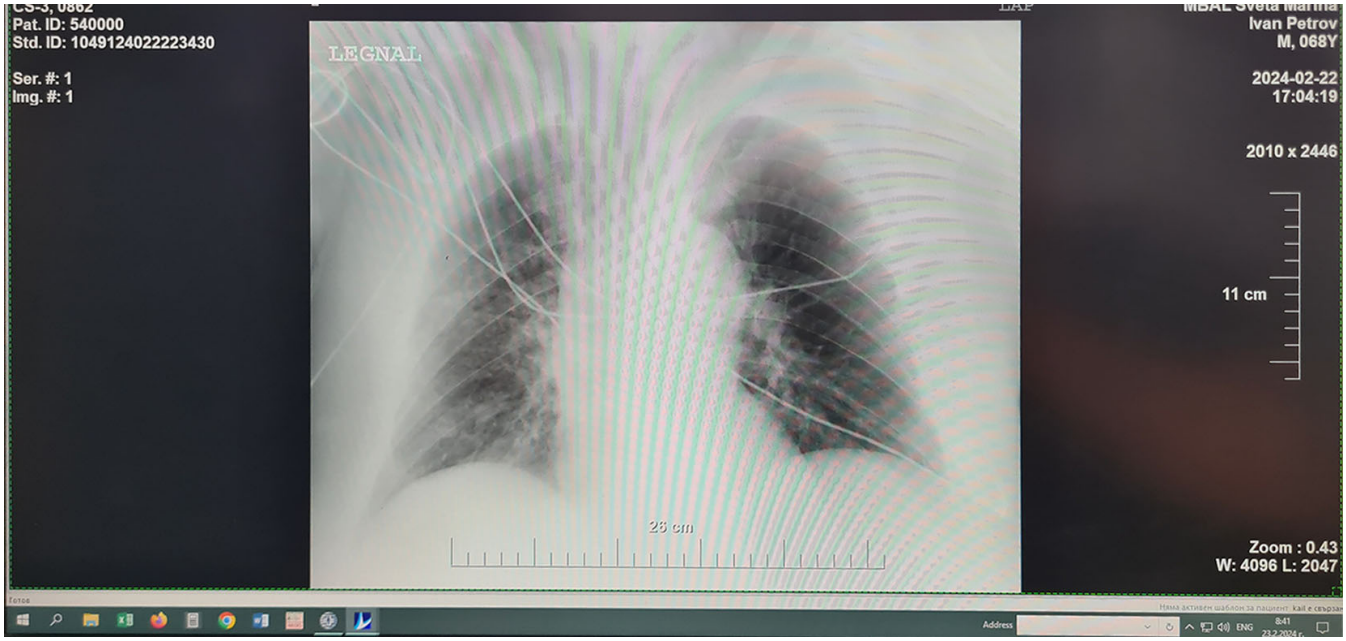
The X-ray showed atelectasis in the right lung, as shown in Figure 1.

Fig. 1 X-ray image before bronchoscopy.



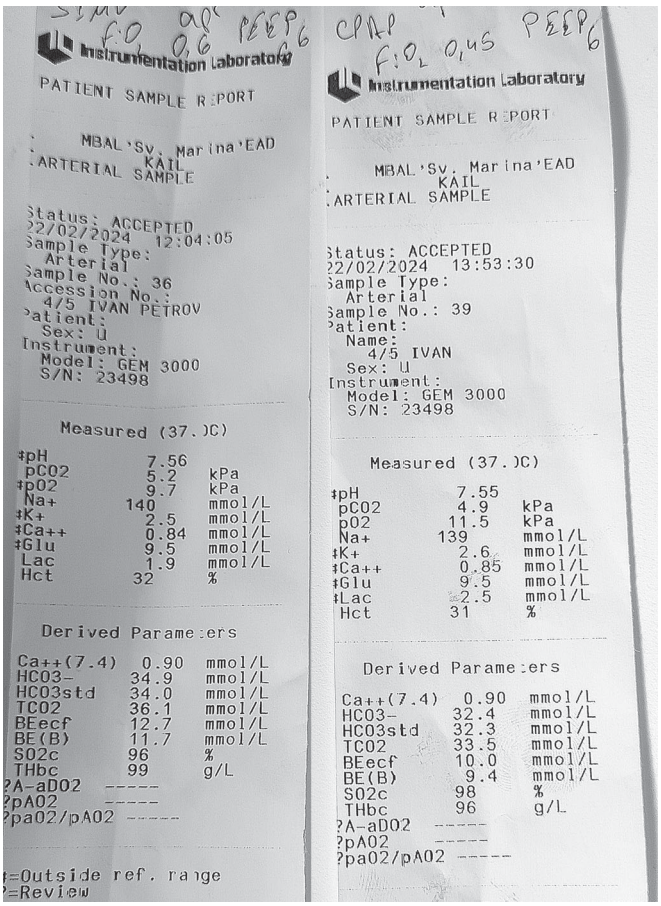
We decided to perform bronchoscopic aspiration for airway desobstruction. The results were significant even after the first BAL. The X-ray has shown an improved pulmonary image (fig. 2).

Fig. 2 X-ray after bronchoscopic aspiration.



Blood oxygenation was also improved, as shown in Figure 3 (arterial blood gas analyses – before and after aspiration).

Fig. 3 Àrterial blood gas analyses – before and after aspiration.



Instrumentation Laboratory

PATIENT SAMPLE REPORT

MBAL'Sv. Marina'EAD
KAIL
ARTERIAL SAMPLE

Status: ACCEPTED
22/02/2024 12:04:05
Sample Type:
Arterial
Sample No.: 36
Accession No.:
4/5 IVAN PETROV
Patient:
Sex: U
Instrument:
Model: GEM 3000
S/N: 23498

Measured (37.0C)

#pH	7.56	
pCO2	5.2	kPa
#pO2	9.7	kPa
Na+	140	mmol/L
#K+	2.5	mmol/L
#Ca++	0.84	mmol/L
#Glu	9.5	mmol/L
Lac	1.9	mmol/L
Hct	32	%

Derived Parameters

Ca++(7.4)	0.90	mmol/L
HCO3-	34.9	mmol/L
HCO3std	34.0	mmol/L
TCO2	36.1	mmol/L
BEecf	12.7	mmol/L
BE(B)	11.7	mmol/L
SO2c	96	%
THbc	99	g/L
?A-aDO2	-----	
?pAO2	-----	
?paO2/pAO2	-----	

?=Outside ref. range
?=Review

Instrumentation Laboratory

PATIENT SAMPLE REPORT

MBAL'Sv. Marina'EAD
KAIL
ARTERIAL SAMPLE

Status: ACCEPTED
22/02/2024 13:53:30
Sample Type:
Arterial
Sample No.: 39
Patient:
Name:
4/5 IVAN
Sex: U
Instrument:
Model: GEM 3000
S/N: 23498

Measured (37.0C)

#pH	7.55	
pCO2	4.9	kPa
pO2	11.5	kPa
Na+	139	mmol/L
#K+	2.6	mmol/L
#Ca++	0.85	mmol/L
#Glu	9.5	mmol/L
#Lac	2.5	mmol/L
Hct	31	%

Derived Parameters

Ca++(7.4)	0.90	mmol/L
HCO3-	32.4	mmol/L
HCO3std	32.3	mmol/L
TCO2	33.5	mmol/L
BEecf	10.0	mmol/L
BE(B)	9.4	mmol/L
SO2c	98	%
THbc	96	g/L
?A-aDO2	-----	
?pAO2	-----	
?paO2/pAO2	-----	

Lung desobstruction improved, and the mechanics of breathing allowed a change in ventilation parameters from SIMV FiO2 0.6 to CPAP FiO2 0.45. This significantly improved the PaO2/PAO2 gradient and PaO2/FiO2 ratio in just one aspiration.

In addition, Acinetobacter baumannii was isolated from the performed BAL and the antibiotic therapy was changed.

In the next days, a total of nine bronchoscopic aspirations were made. On the 28th day of intensive care, we perform a tracheostomy. After sixty-one days in the intensive care unit, the patient was transferred to the Department of Urology with effective breathing and closed tracheostomy. Six days after which, he was discharged from the hospital.

DISCUSSION

Adequate ventilation is a crucial factor in the treatment of patients in intensive care units. There are many developed strategies to achieve adequate gas exchange in these patients, but none of them have proven effectiveness and safety over the others. Several studies have shown that bronchoscopy is clinically beneficial in treating atelectasis in critically ill patients by improving oxygenation (76%), ventilation (59%), or both (49%) for at least 24 hours. In addition, in intubated and pressure control ventilated patients, a significant improvement was found in dynamic compliance, Ppeak, and Pdriving, with positive effects lasting for up to 24 h. Patients with a low baseline recording of PaO2/FiO2 and a high baseline recording of PaCO2 seemed to benefit the most [13, 14]. The other focuses on the short-term evaluation of gas ex-

change, finding no statistically significant results, and reported effects on respiratory mechanics are largely missing [15]. Today, much emphasis is placed on lung-protective ventilation strategies to reduce ventilator-induced lung injury by maintaining alveolar aeration, preventing overexpansion of the lung, and limiting driving pressure. Our results suggest that using bronchoscopy for atelectasis may be an addition to a lung protective strategy when considering the fact that bronchoscopy decreased Ppeak and Pdriving, as required for optimal gas exchange, with results lasting for at least 24 h. This finding merits further studies. To date, there are very few studies investigating the effects of bronchoscopy on gas exchange and respiratory mechanics for up to 24 hours. No data on pulmonary recruitment before or after the procedure is available. This decision was left to the clinical judgment of the attending intensive care physician and is an interesting topic for further investigations. Subsequently, research should focus on patient outcomes such as length of stay and ventilator-free days.

CONCLUSION

In the past decades, interventional pulmonology has experienced remarkable growth in available technology and equipment, as well as clinical and translational research efforts focused on patient-centered outcomes. Recent studies highlight the feasibility of using metagenomics sequencing on BAL for the microbiologic diagnosis of adults with severe community-acquired pneumonia. Moreover, biomarkers and cytokines in BAL fluid may have diagnostic benefits for certain diseases in critically ill patients in the present and near future. The role of FB in the ICU setting has not yet been fully established, but data from the literature suggest that it is an essential tool in a not negligible proportion of pulmonary conditions.

However, standardized protocols on procedure execution as well as decision-making algorithms are currently lacking, leading to hugely different approaches in clinical practice, mainly depending on local sources and expertise availability.

As this field continues to push its boundaries, it is imperative to establish evidence and best practice guidelines. Bronchoscopy can be considered safe in ICU patients, considering the low complication rates.

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