Original Article

Role of Flexible Bronchoscopy in Respiratory Management of Critically Ill Patients: A Retrospective Analysis

Sylvia Sagita Siahaan,*[1] Allen Widysanto,[1] Titis Dewi Wahyuni,[1] Victor Nugroho Wijaya,[1] Magdalena Sirait,[1] Emily Wibowo Otto[2]

[1]Department of Pulmonology and Respiratory Medicine, Faculty of Medicine, Pelita Harapan University, Tangerang
[2]Faculty of Medicine, Pelita Harapan University, Tangerang

Corresponding Author:
Sylvia Sagita Siahaan | Department of Pulmonology and Respiratory Medicine, Faculty of Medicine, Pelita Harapan University, Tangerang | sylvia.siahaan@uph.edu

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Abstract

Background: Respiratory disorders are a major challenge in the ICU, with 30-50% of patients requiring mechanical ventilation. Flexible bronchoscopy provides direct visualization of the airways and plays a critical role in pulmonary diagnosis and therapy. Although widely used in intensive care units (ICUs) worldwide, data on its effectiveness and safety in Indonesian ICUs remain limited.

Method: This is a descriptive, retrospective study using medical records data from patients aged 15 to 85 years who underwent mechanical ventilation in the ICU. Purposive sampling was used, with a sample size of 140. Data were analysed using Microsoft Excel and SPSS.

Results: Of 140 samples, most were male (65%), with a mean age of 57.64 years. Comorbidities were present in 83.7%, primarily cardiovascular disease (28.8%). The most common indication was combined diagnostic and therapeutic purposes (45.7%). Chest X-ray improvement was observed in 75.7% of patients. FiO_2 requirements increased after bronchoscopy. Most bronchoscopy findings indicated infection (60%), and hypoxemia was the most frequent complication (9.3%).

Conclusion: Flexible bronchoscopy is a safe and effective diagnostic and therapeutic procedure.

Keywords: bronchoscopy, flexible bronchoscopy, intensive care unit

INTRODUCTION

Respiratory disorders remain a major challenge in the management of intensive care unit (ICU) patients. Approximately 30-50% of ICU patients experience respiratory failure requiring mechanical ventilation. Advances in medical technology have enhanced the ability to perform accurate, minimally invasive evaluations of the tracheobronchial tree, enabling diagnostic, therapeutic, and even palliative interventions. According to Patolia et al, the prevalence of bronchoscopy use among ICU patients receiving mechanical ventilation ranges from 65% to 79%.[1]

Bronchoscopy is an essential procedure for pulmonologists and critical

care physicians in diagnosing and managing various pulmonary diseases. It provides direct visualization of the lower airways, which is particularly valuable for evaluating conditions such as airway obstruction, foreign bodies, and pneumonia. It can also be used therapeutically for conditions such as hemoptysis and mucus plugs. Nevertheless, potential complications may occur, including hypoxemia, arrhythmias, and bleeding, particularly in high-risk patients.[2]

The convenience and practicality of bedside flexible bronchoscopy (FOB) make it a preferred procedure in ICU settings, provided that the potential risks and complications are well managed. The diagnostic utility of bronchoscopy includes conditions such as atelectasis, hemoptysis, and airway obstruction, while its therapeutic applications involve airway clearance, control of bleeding, and management of difficult intubation.[3]

In Indonesia, research on bronchoscopy has been limited, particularly in non-COVID-19 ICU patients. Therefore, this study was conducted to evaluate the role of flexible bronchoscopy in the ICU of Siloam Hospital Lippo Village. The study analysed multiple variables, including patient demographics, comorbidities, indications, chest X-ray findings, arterial blood gas results, mechanical ventilation parameters, bronchoscopy findings, and associated complications.

This research is significant, not only for providing descriptive data but also for assessing the effectiveness and safety of flexible bronchoscopy in the ICU setting in Indonesia, where evidence remains scarce. The findings are expected to offer valuable insight into the clinical impact of bronchoscopy on parameters such as gas exchange, radiologic outcomes, and ventilatory function, thereby supporting evidence-based clinical decision-making in critical care practice.

METHOD

This study employed a descriptive retrospective design in the Endoscopy Unit and the Medical Records Department of Siloam Hospital Lippo Village between January and April 2025. The procedures were performed by pulmonologists using Olympus bronchoscopy with a standard sterilization procedure. The ethics were approved by the hospital and the Faculty of Medicine, Pelita Harapan University (311/K-LKJ/ETIK/XII/2024).

The study population consisted of all ICU patients aged 15 to 85 years who underwent FOB while receiving mechanical ventilation. The study sample was selected using a purposive sampling technique used to obtain complete data from medical records.

The inclusion criteria were patients aged 15-85 years admitted to the ICU of Siloam Hospital Lippo Village who were undergoing mechanical ventilation and had clinical indications for bronchoscopy. Patients with incomplete, illegible, or unclear records were excluded from the study. The minimum sample size required

was 139 subjects, calculated based on the estimated prevalence of bronchoscopy use among mechanically ventilated ICU patients, and the final number of cases analysed was 140.

This study utilized secondary data obtained from patient electronic and paper-based medical records. The retrieved data included demographic characteristics, comorbidities, indications for bronchoscopy, chest X-ray findings, blood gas analysis, mechanical ventilation parameters, bronchoscopy results, and complications.

All collected data were tabulated using Microsoft Excel and statistically analysed using SPSS version 27.0. Continuous variables were presented as means and range (min-max), whereas categorical variables were presented as frequencies and percentages. Pre- and post-bronchoscopy comparisons for chest X-ray, arterial blood gas parameters, and mechanical ventilation parameters were analysed using paired t-tests to assess differences before and after intervention. A value of $P<0.05$ was considered statistically significant.

RESULT

This study included 140 patients who underwent FOB in the ICU of Siloam Hospital Lippo Village. The mean age was 57.64 years (range=15-85 years), with 65.0% males and 35.0% females. Most patients (83.7%) had at least one comorbidity, most commonly cardiovascular disease (28.8%). The primary indications for bronchoscopy were combined diagnostic and therapeutic purposes (45.7%). Radiographic findings demonstrated post-procedure improvement in 75.7% of patients on chest x-ray, while 24.3% showed deterioration (Table 1).

Table 1. Demographic and clinical characteristics of patients

Variable	n	%
Age, mean (range)	57.64 (15-85)	
Gender		
Male	91	65.0
Female	49	35.0
Comorbidities		
Cardiovascular diseases	62	28.8
Diabetes mellitus	32	14.9
Other chronic diseases	32	14.9
Other acute diseases	29	13.5
COPD	12	5.6
Malignancy	8	3.7
Autoimmune diseases	5	2.3
Indication		
Combined	64	45.7
Diagnostic	50	35.7
Therapeutic	26	18.6
Chest X-ray		
Improvement	106	75.7
Deterioration	34	24.3

Note: COPD=chronic obstructive pulmonary disease

Analysis of arterial blood gases (ABG) and mechanical ventilator settings before and after bronchoscopy revealed no statistically significant difference in most parameters (pH, $PaCO_2$, PaO_2, HCO_3^-, and Positive End-Expiratory Pressure/PEEP). However, there was a significant increase in FiO_2 after bronchoscopy ($P=0.047$). This increase was attributed to the use of 100% oxygen supplementation during the procedure to minimize hypoxemia from transient airway obstruction. The ABG was taken within 24 hours pre-and post-bronchoscopy (Table 2).

Table 2. Comparison of arterial blood gases and mechanical ventilator settings before and after bronchoscopy

Arterial Blood Gases	Before Bronchoscopy [Mean (Range)]	After Bronchoscopy [Mean (Range)]	P
pH	7.44 (7.15-7.72)	7.44 (7.01-7.68)	0.861
$PaCO_2$	41.53 (20.6-74)	42.33 (20.4-138)	0.476
PaO_2	127.13 (35.8-317)	132.24 (21.9-469)	0.371
HCO_3^-	27.75 (14.2-48.4)	28.15 (14.6-44.1)	0.225
FiO_2	52.31 (29-100)	54.47 (29-100)	0.047*
PEEP	5.69 (5-10)	5.74(5-10)	0.441

Note: *significant with P<0.05; PEEP=Positive End-Expiratory Pressure

Table 3. Results of bronchoscopies

Results	n (%)
Infection	84 (60.0%)
Airway stenosis diagnosis	20 (14.3%)
Diagnosis cause of hemoptysis/intervention	16 (11.4%)
Malignancy	15 (10.7%)
Nonconclusive for bilateral infiltrates	5 (3.6%)

Bronchoscopy findings demonstrated that infection-related abnormalities were the most common (60.0%) (Table 3). Meanwhile, complications occurred in 22.8% of patients, with the most frequent being hypoxemia (9.3%) (Table 4). All complications were managed conservatively, and no procedure-related mortality occurred. The complication rates were comparable to international data, reaffirming the FOB is a safe and effective procedure when performed under careful monitoring in the ICU.

Table 4. Complications of bronchoscopies

Complications	n (%)
Hypoxemia	13 (9.3%)
Tachycardia	9 (6.4%)
Bleeding	5 (3.6%)
Bradycardia	3 (2.1%)
Pneumothorax	2 (1.4%)

DISCUSSION

This study evaluated the role of FOB in the ICU of Siloam Hospital Lippo Village, and the procedure provides both diagnostic and therapeutic benefits with acceptable safety outcomes. The findings showed that most patients were male (65.0%). This finding is consistent with a study by Korraa et al, who reported a higher proportion of male patients (66.3%) undergoing bronchoscopy.[4] The predominance of males may be related to higher exposure to risk factors such as smoking and occupational exposure to carcinogenic substances.[5] Similarly, data from the Global Cancer Observatory in 2022 indicate that lung cancer is more prevalent in men (15.2%) than in women (9.4%).[6]

Although bronchoscopy is generally a safe procedure, complications can occur, particularly among patients with comorbidities. In this study, most patients (83.7%) had at least one comorbidity, primarily cardiovascular disease (28.8%), being the most common comorbidity. These findings align with a study by Tanriverdi et al, showing that cardiovascular disorders are the most frequent comorbidities among elderly bronchoscopy patients.[7]

Despite the overall safety of the procedure, patients with significant cardiac disease remain at higher risk due to hemodynamic instability and reduced

tolerance to hypoxemia. These patients also have limited cardiopulmonary reserve, necessitating careful monitoring during bronchoscopy.[8,9]

Diabetes mellitus was the second most common comorbidity (14.9%). Diabetes can impair pulmonary function through inflammation, oxidative stress, and immune dysfunction, leading to reduced respiratory muscle strength and decreased vital capacity (FVC).[10] Moreover, diabetic patients are most susceptible to respiratory infections and exhibit delayed tissue healing, which may influence bronchoscopy outcomes.[11]

The primary indication for bronchoscopy in this study was combined diagnostic and therapeutic purposes (45.7%). This pattern reflects that bronchoscopy is both a safe and effective procedure for diagnosis and treatment. Performing combined diagnostic and therapeutic interventions in a single session enhances efficiency, reduces procedural risks, and lowers overall patient care costs.[12,13] This combined approach is particularly beneficial in cases such as massive hemoptysis, mucus plugging, or malignancy, where bronchoscopy can simultaneously clear the airway and obtain biopsy samples.[14]

In patients with central airway obstruction (CAO), for example, bronchoscopy allows debridement, mucus plug aspiration, and airway stent placement.[15] Moreover, advances such as endobronchial ultrasound (EBUS) have expanded the diagnostic capability of bronchoscopy, enabling simultaneous diagnosis and staging of lung cancer.[16] Over time, bronchoscopy has evolved from a purely visual diagnostic tool into a sophisticated therapeutic intervention, incorporating techniques such as laser ablation, argon plasma coagulation (APC), and intrabronchial brachytherapy.[17]

Furthermore, more patients in this study showed improvement on chest X-ray (75.7%). This is similar to a previous study by Achhava et al, which stated that approximately 63.8% of patients showed post-procedure clinical and radiological improvement in terms of air entry and chest X-ray findings after bronchoscopy in the ICU.[18] Conversely, 34 patients (24.3%) experienced worsening chest X-ray results, which may reflect the natural progression of the underlying disease or post-bronchoscopy complications. Overall, these results support the effectiveness of bronchoscopy as both a diagnostic and therapeutic procedure.

Then, a paired t-test analysis was performed to compare arterial blood gas and mechanical ventilation parameters before and after bronchoscopy, and the results showed no statistically significant difference in most parameters (pH, $PaCO_2$, PaO_2, HCO_3^-, and PEEP), except for FiO_2, which showed a significant increase ($P=0.047$). This finding may be caused by the routine administration of 100% FiO_2 during bronchoscopy to prevent hypoxemia caused by airway obstruction from the bronchoscope or sedative effects during the procedure.[1]

Increasing FiO_2 before and during bronchoscopy is a well-established

preventive measure to enhance oxygen reserves and minimize the risk of hypoxemia, and it is recommended to administer supplemental oxygen for approximately 15 minutes before the procedure.[1] Additionally, flexible bronchoscopy can increase airway resistance and reduce tidal volume, especially when performed through an endotracheal tube (ETT), thereby necessitating a temporary increase in FiO_2 to maintain adequate oxygenation.[1,19]

The most frequent bronchoscopic findings in this study were infection-related abnormalities (60.0%), which is consistent with the role of bronchoscopy as a diagnostic tool for identifying pulmonary infections such as pneumonia, tuberculosis, and other infectious diseases.[20] Other findings included airway stenosis (14.3%), diagnostic cause of hemoptysis/ intervention (11.4%), malignancy (10.7%), and non-conclusive for bilateral infiltrates (3.6%).

These results differ from the findings of Korraa et al, who identified malignancy as the most frequent bronchoscopy diagnosis. The discrepancy may be attributed to differences in patient characteristics, comorbidities, and procedural indications, since the present study involved both diagnostic and therapeutic purposes, whereas Korraa et al focused mainly on diagnostic indications.[4] Epidemiological variations and disease prevalence in different hospitals or regions may also influence the spectrum of findings.

In this study, bronchoscopy-related complications occurred in 32 patients (22.8%). The most common complication was hypoxemia (9.3%). These findings are consistent with a study from Vasko et al, which observed that hypoxemia occurred in 2.5-69.0% of bronchoscopy cases.[21] Hypoxemia during bronchoscopy is typically caused by ventilation-perfusion mismatch, which can be triggered by bronchoconstriction reflexes due to mechanical stimulation of subepithelial receptors by bronchoscopes.[19]

Bronchoscopy complications may arise from both patient-related and procedural factors. Advanced age, cardiopulmonary comorbidities, and prolonged procedure duration are known risk factors.[2] Therefore, a comprehensive pre-procedural evaluation, including assessment of comorbidities, indications, contraindications, and pulmonary function, is essential to minimize risks.[22]

The use of appropriate anesthetic techniques, such as administering 100% oxygen during the procedure, can reduce the likelihood of hypoxemia.[22] In cases of bleeding, management options include instillation of adrenaline solution, direct pressure with the bronchoscope tip, or balloon tamponade to control active hemorrhage.[23]

The limitation of this study lies in the incomplete availability of data required for several research variables, making it difficult to obtain information that fully matches the study parameters and introducing bias. Some variables, such as chest X-ray findings, arterial blood gas, and

mechanical ventilation parameters before and after bronchoscopy, as well as bronchoscopy results, were missing or incomplete in the available medical records.

CONCLUSION

Flexible bronchoscopy diagnostic and therapeutic procedures were associated with clinical and radiologic improvement in mechanically ventilated ICU patients and showed a low complication rate in this study population. Nevertheless, due to the retrospective descriptive nature of the study, causal inferences regarding effectiveness and safety cannot be established. Further prospective studies are warranted to confirm these findings.

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