

Association Between Oxygen Saturation Levels and Post-Bronchoscopy Adverse Events in Intensive Care Unit Patients at H. Adam Malik General Hospital

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ABSTRACT

Introduction: Bronchoscopy is widely performed for diagnostic and therapeutic purposes in critically ill patients; however, it may cause oxygen desaturation and post-procedural adverse events, particularly in those with limited respiratory reserve. To evaluate the association between oxygen saturation levels and post-bronchoscopy adverse events among intensive care unit (ICU) patients at H. Adam Malik General Hospital.

Methods: This observational analytic study used a cross-sectional design and included 46 ICU patients who underwent bronchoscopy, recruited by consecutive sampling. Data were obtained from medical records and direct intraprocedural observation. Univariable and bivariable analyses were performed, with statistical significance set at $p < 0.05$.

Results: Most patients were male (52.2%) and had no smoking history (60.9%); bronchoalveolar lavage was the most common procedure (91.3%), and pneumonia was the most frequent diagnosis (63.0%). Oxygen saturation was normal in 93.5% of patients before bronchoscopy but in only 34.8% during the procedure, returning to normal in 91.3% afterward. Post-bronchoscopy adverse events occurred in 31 patients (67.4%), most commonly cough (32.6%), dyspnea (15.2%), desaturation (8.7%), and hemoptysis (6.5%). Oxygen saturation levels during bronchoscopy ($p = 0.001$) and intraprocedural desaturation ($p < 0.001$) were significantly associated with adverse events, whereas pre- and post-bronchoscopy saturation, FiO_2 , and bacterial growth were not. The multivariable logistic regression model was not statistically significant overall ($p = 0.100$).

Conclusion: Oxygen saturation levels and desaturation during bronchoscopy were significantly associated with post-bronchoscopy adverse events in ICU patients. Intra-procedural decreases in oxygen saturation should be anticipated through close oxygenation monitoring before, during, and after the procedure.

Bronchoscopy, Oxygen Saturation, Hypoxemia, Intensive Care Unit, Adverse Events

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INTRODUCTION

Bronchoscopy is a minimally invasive procedure in which a flexible endoscope is advanced into the tracheobronchial tree to visualize the lower respiratory tract and obtain specimens for further evaluation [1]. It has become an indispensable diagnostic and therapeutic tool in the management of critically ill patients admitted to the intensive care unit (ICU), where it is widely used to sample the lower airways, identify pathogens responsible for pneumonia and ventilator-associated pneumonia, clear retained secretions, and manage atelectasis and mucus plugging [2,3]. In mechanically ventilated patients, flexible bronchoscopy can be performed safely at the bedside and frequently alters clinical management, which explains its expanding role in contemporary critical care [4].

Despite its clinical value, bronchoscopy is not without risk, and oxygen desaturation is consistently reported as one of its most frequent adverse events [5,6]. Passage of the bronchoscope through an artificial or natural airway reduces the effective cross-sectional area available for ventilation, while suctioning, instillation of bronchoalveolar lavage fluid, and procedural sedation further impair gas exchange and may precipitate hypoxemia [7,8]. Clinically significant desaturation can destabilize an already tenuous physiological balance, particularly in patients with limited respiratory reserve, and has been linked to an increased risk of post-procedural complications [5]. Critically ill patients are especially vulnerable to these events because underlying conditions such as severe pneumonia, acute respiratory distress syndrome (ARDS), chronic obstructive pulmonary disease (COPD), and respiratory failure already compromise oxygenation before the procedure begins [9,10]. Several investigators have reported that hypoxemia during bronchoscopy is common and is influenced by the patient's baseline clinical status, the type of procedure performed, the depth of sedation, and the mode of oxygenation support [11]. A range of strategies—including high-flow nasal cannula oxygen, non-invasive ventilation, and pre-procedural optimization of the fraction of inspired oxygen (FiO_2)—has been proposed to mitigate desaturation, underscoring the clinical importance of anticipating and monitoring oxygenation throughout the procedure [12,13].

Although the association between intraprocedural oxygen saturation and adverse outcomes has been examined in general bronchoscopy populations, data specific to critically ill ICU patients—the group at the greatest physiological risk—remain limited [14]. Therefore, characterizing this association in the ICU setting is clinically relevant and may inform peri-procedural monitoring and oxygenation strategies. Accordingly, this study evaluated the association between oxygen saturation levels and post-bronchoscopy adverse events among ICU patients at H. Adam Malik General Hospital, Medan. The primary objective of this study was to determine the association between oxygen saturation levels and post-bronchoscopy adverse events among patients admitted to the intensive care unit (ICU) of H. Adam Malik General Hospital.

METHODS

Study Design and Participants

This observational analytic study used a cross-sectional design and was conducted at H. Adam Malik General Hospital, Medan, after approval was obtained from the Health Research Ethics Committee of the Faculty of Medicine, Universitas Sumatera Utara / H. Adam Malik General Hospital. The study was conducted from July to August 2025. The study population comprised all patients who underwent bronchoscopy at H. Adam Malik General Hospital. Eligible participants were adult patients admitted to the ICU who underwent bronchoscopy during the study period. Consecutive sampling was used. The inclusion criteria were age ≥ 18 years, undergoing bronchoscopy, availability of complete data, and willingness to participate. Patients aged < 18 years, those who declined participation, and those with incomplete data were excluded. The minimum required sample size was 46 patients.

Study Variables

The independent variable was the oxygen saturation level during bronchoscopy, and the dependent variable was the occurrence of post-bronchoscopy adverse events. Other variables included age, sex, educational attainment, smoking history, comorbidities, and the timing of desaturation. Oxygen saturation was measured using pulse oximetry and categorized as normal, mild-to-moderate hypoxemia, moderate-to-severe hypoxemia, or severe/life-threatening hypoxemia. Post-bronchoscopy adverse events were identified from clinical manifestations, such as severe cough, dyspnea, or bleeding after the procedure.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics version 26. Categorical variables are presented as frequencies and percentages, whereas numerical variables are presented as mean $\pm$ standard deviation or median and interquartile range according to data distribution. The mean age was compared between patients with and without adverse events using an independent-samples t-test. Associations between categorical variables and

post-bronchoscopy adverse events were assessed using Pearson's chi-square test or Fisher's exact test when the assumptions of the chi-square test were not satisfied. Multivariable analysis was performed using binary logistic regression with the Enter method, and the results are presented as adjusted odds ratios (ORs) with 95% confidence intervals (CIs). Model performance was assessed using the Omnibus Test of Model Coefficients, $-2 \log$ likelihood, Cox and Snell R^2 , Nagelkerke R^2 , and overall classification accuracy. All tests were two-sided, and statistical significance was set at $p < 0.05$.

RESULTS

Patient and Bronchoscopy Characteristics

A total of 46 patients in the intensive care unit (ICU) who underwent bronchoscopy at H. Adam Malik General Hospital were included in the study, and complete data were available for all participants. Most patients were male (24 patients; 52.2%), had completed senior high school (35 patients; 76.1%), and had no history of smoking (28 patients; 60.9%). Pneumonia was the most common primary pulmonary diagnosis (29 patients; 63.0%), whereas neurological disorders, head trauma, or post-neurosurgical conditions were the most common non-pulmonary comorbidities (28 patients; 60.9%).

Bronchoalveolar lavage (BAL) was the most frequently performed bronchoscopic procedure (42 patients, 91.3%), whereas BAL combined with brushing was performed in four patients (8.7%). Most procedures were performed using an endotracheal tube (39 patients, 84.8%), and a 7.5-mm endotracheal tube was the most commonly used size (25 patients, 54.3%).

Table 1. Patient and Bronchoscopy Characteristics

Characteristic	n	%
Sex		
Male	24	52.2
Female	22	47.8
Educational attainment		
Primary school	4	8.7
Junior high school	4	8.7
Senior high school	35	76.1
Bachelor's degree	3	6.5
Smoking history		
Current/former smoker	18	39.1
Never smoker	28	60.9
Primary pulmonary diagnosis		
Pneumonia	29	63.0
ARDS/respiratory failure	7	15.2
Atelectasis/sputum retention/mucus plug	3	6.5
Airway foreign body	2	4.3
Pulmonary tuberculosis	2	4.3
Pulmonary malignancy/tumor	2	4.3
COPD exacerbation	1	2.2
Non-pulmonary comorbidity		
Neurological disorder/head trauma/post-neurosurgical	28	60.9
Cardiac/cardiovascular disease	6	13.0
Sepsis/septicemia/septic shock	3	6.5
Non-pulmonary malignancy	3	6.5
No non-pulmonary comorbidity	3	6.5
Obstetric/gynecological comorbidity	2	4.3
Renal/metabolic disorder	1	2.2
Bronchoscopic procedure		
BAL	42	91.3
BAL + brushing	4	8.7
Airway access		
Endotracheal tube	39	84.8
Tracheostomy	7	15.2

Notes: ARDS, acute respiratory distress syndrome; BAL, bronchoalveolar lavage; COPD, chronic obstructive pulmonary disease.

Changes in Oxygen Saturation and FiO₂

Before bronchoscopy, oxygen saturation was normal in 43 patients (93.5%). During bronchoscopy, the number of patients with normal oxygen saturation decreased to 16 (34.8%), mild hypoxemia occurred in eight patients (17.4%), moderate hypoxemia in 14 (30.4%), and severe or life-threatening hypoxemia in eight (17.4%). After bronchoscopy, oxygen saturation returned to normal in 42 patients (91.3%).

The most common pre-bronchoscopy FiO₂ category was 41–60%, which was observed in 17 patients (37.0%). During bronchoscopy, FiO₂ ≤40% was used in 16 patients (34.8%), whereas FiO₂ 61–80% was used in 14 patients (30.4%). After bronchoscopy, FiO₂ ≤40% was used in 17 patients (37.0%).

Table 2. Distribution of Oxygen Saturation and FiO₂ Before, During, and After Bronchoscopy

Variable	Pre	During	Post
Oxygen saturation			
Normal, SpO ₂ 95–100%	43 (93.5)	16 (34.8)	42 (91.3)
Mild hypoxemia, SpO ₂ 90–94%	3 (6.5)	8 (17.4)	3 (6.5)
Moderate hypoxemia, SpO ₂ 85–89%	0 (0.0)	14 (30.4)	0 (0.0)
Severe/life-threatening, SpO ₂ <85%	0 (0.0)	8 (17.4)	1 (2.2)
FiO ₂			
≤40%	16 (34.8)	16 (34.8)	17 (37.0)
41–60%	17 (37.0)	12 (26.1)	16 (34.8)
61–80%	9 (19.6)	14 (30.4)	9 (19.6)
81–100%	4 (8.7)	4 (8.7)	4 (8.7)

Post-Bronchoscopy Adverse Events

Post-bronchoscopy adverse events occurred in 31 patients (67.4%), whereas 15 patients (32.6%) experienced no adverse events. The most frequent adverse event was cough (15 patients; 32.6%), followed by dyspnea (7 patients; 15.2%), desaturation (4 patients; 8.7%), and hemoptysis (3 patients; 6.5%). Bleeding and chest pain each occurred in one patient (2.2%).

Table 3. Distribution of Post-Bronchoscopy Adverse Events

Adverse event	n	%
Cough	15	32.6
Dyspnea	7	15.2
Desaturation	4	8.7
Hemoptysis	3	6.5
Bleeding	1	2.2
Chest pain	1	2.2
No adverse event	15	32.6
Total	46	100.0

Factors Associated With Post-Bronchoscopy Adverse Events

The mean age of patients who experienced adverse events was 47.65±21.63 years, compared with 43.40±17.56 years among those without adverse events; the difference was not statistically significant (P=0.512). Adverse events occurred in 14 of 24 male patients (58.3%) and 17 of 22 female patients (77.3%), and sex was not significantly associated with post-bronchoscopy adverse events (P=0.171). Educational attainment (p=0.137) and smoking history (p=0.170) were not significantly associated with adverse events.

Desaturation during bronchoscopy was significantly associated with post-bronchoscopy adverse events (p<0.001); adverse events occurred in 26 of 30 patients (86.7%) who developed desaturation, compared with 5 of 16 patients (31.3%) who did not. Analysis by oxygen saturation category also demonstrated a significant association (p=0.001), with adverse events in 6 of 18 patients (33.3%) with normal saturation, 23 of 26 patients (88.5%) with mild-to-moderate hypoxemia, and all patients with severe or life-threatening hypoxemia. Pre-bronchoscopy saturation (p=1.000), post-bronchoscopy saturation (p=0.346), pre-bronchoscopy FiO₂ (p=0.491), and post-bronchoscopy FiO₂ (p=0.502) were not significantly associated with any adverse events.

Table 4. Bivariable Analysis of Factors Associated With Post-Bronchoscopy Adverse Events

Variable	Category	AE+	AE-	p-value
Age, years	Mean±SD	47.65±21.63	43.40±17.56	0.512 ^a
Sex	Male	14 (58.3)	10 (41.7)	0.171 ^b
	Female	17 (77.3)	5 (22.7)	
Education	Primary	1 (25.0)	3 (75.0)	0.137 ^b
	Junior high	2 (50.0)	2 (50.0)	
	Senior high	25 (71.4)	10 (28.6)	
	Bachelor's	3 (100.0)	0 (0.0)	
Smoking history	Current/former	10 (55.6)	8 (44.4)	0.170 ^b
	Never	21 (75.0)	7 (25.0)	
Procedure desaturation	Absent	5 (31.3)	11 (68.8)	<0.001 ^b
	Present	26 (86.7)	4 (13.3)	
SpO ₂ category	Normal	6 (33.3)	12 (66.7)	0.001 ^b
	Mild-moderate	23 (88.5)	3 (11.5)	
	Severe	1 (100.0)	0 (0.0)	
	Life-threatening	1 (100.0)	0 (0.0)	
Pre-bronchoscopy SpO ₂	Normal	29 (67.4)	14 (32.6)	1.000 ^c
	Mild hypoxemia	2 (66.7)	1 (33.3)	
Post-bronchoscopy SpO ₂	Normal	29 (69.0)	13 (31.0)	0.346 ^b
	Mild hypoxemia	1 (33.3)	2 (66.7)	
	Life-threatening	1 (100.0)	0 (0.0)	

Notes: Data are presented as n (%) unless otherwise indicated. AE, adverse event. ^aIndependent-samples t-test; ^bchi-square test; ^cFisher's exact test. Bold p-values indicate statistical significance (p<0.05).

Microbiological Findings

Bacterial growth was detected in 36 (78.3%) patients, whereas no growth was identified in 10 (21.7%) patients. The most frequently isolated microorganism was *Acinetobacter baumannii* (13 patients, 28.3%), followed by *Pseudomonas aeruginosa* (10 patients, 21.7%) and *Klebsiella pneumoniae* ssp. *pneumoniae* (7 patients, 15.2%). Adverse events occurred in 23 of 36 patients (63.9%) with bacterial growth and in 8 of 10 patients (80.0%) without bacterial growth. Fisher's exact test showed no significant association between bacterial growth and post-bronchoscopy adverse events (p=0.460).

Table 5. Distribution of Microbiological Findings

Microbiological finding	n	%
<i>Acinetobacter baumannii</i>	13	28.3
<i>Pseudomonas aeruginosa</i>	10	21.7
No bacterial growth	10	21.7
<i>Klebsiella pneumoniae</i> ssp. <i>pneumoniae</i>	7	15.2
<i>Pseudomonas putida</i>	1	2.2
<i>Serratia marcescens</i>	1	2.2
<i>Corynebacterium striatum</i>	1	2.2
<i>Burkholderia cepacia</i>	1	2.2
<i>Proteus mirabilis</i>	1	2.2
<i>Escherichia coli</i>	1	2.2
Total	46	100.0

Multivariable Analysis

The logistic regression model included age, sex, educational attainment, pre-bronchoscopy FiO₂, post-bronchoscopy FiO₂, and bacterial growth. The model converged with a -2 log likelihood of 47.450; Cox and Snell R² was 0.206, and Nagelkerke R² was 0.288, indicating that the model explained approximately 20.6–28.8% of the variation in post-bronchoscopy adverse event status, with an overall classification accuracy of 76.1%. The Omnibus Test of Model Coefficients yielded $\chi^2=10.636$, df=6, and p=0.100; thus, the model did not provide a statistically significant improvement in predictive ability compared to the intercept-only model. In the partial analysis, educational attainment was statistically significant (p=0.044; Exp(B)=0.263; 95% CI 0.071–0.967), whereas age, sex, pre- and post-bronchoscopy FiO₂, and bacterial growth were not. This result should be interpreted cautiously because the overall regression model was not significant in this study.

Table 6. Logistic Regression Analysis of Factors Associated With Post-Bronchoscopy Adverse-Event Status

Variable	B	S.E.	Wald	p-value	Exp(B)	95% CI
Age	-0.014	0.019	0.556	0.456	0.986	0.950–1.023
Sex	-1.222	0.794	2.368	0.124	0.295	0.062–1.397
Education	-1.337	0.665	4.045	0.044	0.263	0.071–0.967
Pre-bronchoscopy FiO ₂	-0.017	0.026	0.438	0.508	0.983	0.935–1.034
Post-bronchoscopy FiO ₂	-0.001	0.026	0.001	0.973	0.999	0.949–1.052
Bacterial growth	1.242	1.073	1.340	0.247	3.463	0.423–28.354

Notes: Model statistics: Omnibus test $\chi^2=10.636$; $df=6$; $p=0.100$; $-2 \log \text{likelihood}=47.450$; Cox and Snell $R^2=0.206$; Nagelkerke $R^2=0.288$. The dependent variable was coded as 0 for adverse events and 1 for no adverse events. A bold p-value indicates statistical significance ($p<0.05$).

DISCUSSION

Most patients who underwent bronchoscopy at H. Adam Malik General Hospital were male, had completed senior high school, and had no history of smoking. The predominance of male patients is consistent with previous studies reporting that men are more likely to undergo bronchoscopy because chronic pulmonary diseases and respiratory disorders are more prevalent in this group [15,16]. Most patients also experienced desaturation during the procedure, suggesting that oxygen saturation most commonly declined during bronchoscopy because of transient ventilation impairment, sedation, or pre-existing pulmonary dysfunction [6].

Desaturation during bronchoscopy occurred in 30 patients (65.2%). Oxygen desaturation is a relatively common complication of bronchoscopy and may result from partial airway obstruction by the bronchoscope, hypoventilation, sedative effects, and underlying pulmonary disease [10]. This finding is consistent with that of Zhang et al. and Putri et al., who identified hypoxemia as one of the most frequent complications during bronchoscopy [11]. The most frequently performed procedure was bronchoalveolar lavage (BAL), accounting for 91.3% of cases, whereas BAL combined with brushing was performed in 8.7% of patients. In critically ill patients, BAL is commonly used to obtain lower respiratory tract specimens, identify the cause of pneumonia or ventilator-associated pneumonia, and facilitate secretion clearance in patients with atelectasis or sputum retention [17]. The absence of biopsy and transbronchial needle aspiration procedures may reflect concerns regarding bleeding, hypoxemia, and clinical instability in ICU patients [3]. Most bronchoscopies were performed through an endotracheal tube, and a 7.5-mm tube was the most commonly used size (54.3%). Introducing a bronchoscope through an endotracheal tube reduces the effective airway cross-sectional area, increases resistance, and may reduce effective tidal volume. The outer diameter of the bronchoscope should therefore be selected in relation to the size of the artificial airway to maintain adequate ventilation throughout the procedure [18].

Pneumonia was the most common primary pulmonary diagnosis (63.0%). This finding is consistent with the use of bronchoscopy for diagnostic and therapeutic purposes in ICU patients with severe pneumonia, respiratory failure, secretion retention, and atelectasis [19,20]. Neurological disorders, head trauma, and post-neurosurgical conditions were the most common non-pulmonary comorbidities (60.9%). Patients with severe neurological impairment often have diminished cough reflexes, impaired airway protection, immobility, and a need for mechanical ventilation, making them more susceptible to aspiration, secretion retention, pneumonia, and respiratory failure [21,22]. Cardiovascular and other systemic comorbidities may further reduce physiological reserve and increase the risk of impaired oxygenation during bronchoscopy [12]. Before bronchoscopy, oxygen saturation was normal in 93.5% of patients; however, these measurements were obtained while patients were receiving oxygenation support through mechanical ventilation, an endotracheal tube, tracheostomy, a T-piece, or another oxygen-delivery device. During bronchoscopy, the proportion of patients with normal oxygen saturation decreased to 34.8%, whereas mild, moderate, and severe or life-threatening hypoxemia occurred in 17.4%, 30.4%, and 17.4%, respectively. After bronchoscopy, oxygen saturation returned to normal in 91.3% of patients. This pattern indicates that oxygenation impairment occurred predominantly during the procedure and improved after its completion in most patients. Oxygen saturation may decline during bronchoscopy because the bronchoscope narrows the airway lumen, suction is applied, BAL fluid is instilled, lung volume decreases, ventilation-perfusion mismatch develops, or sedation suppresses

ventilation. The risk is greater in patients with severe pneumonia, ARDS, respiratory failure, atelectasis, COPD, pulmonary tuberculosis, or lung malignancy because their respiratory reserve is already limited [6]. This finding is consistent with reports by Zhang et al. and Putri et al. showing that desaturation is an important complication of bronchoscopy and is influenced by clinical condition, procedure type, sedation, and oxygenation support [10].

Post-bronchoscopy adverse events occurred in 31 patients (67.4%), with the most frequent being cough (32.6%), dyspnea (15.2%), desaturation (8.7%), hemoptysis (6.5%), bleeding (2.2%), and chest pain (2.2%). The high frequency of adverse events may be related to the severity of illness and limited baseline respiratory function in ICU patients. Mucosal irritation, suction, bronchoalveolar lavage (BAL), and sedation may also provoke cough, bronchospasm, dyspnea, minor bleeding, and impaired oxygenation [23]. Bronchoscopy in ICU patients is associated with a higher risk of respiratory compromise than in non-ICU patients because critically ill patients generally have more severe and unstable conditions [14]. Oxygen saturation levels during bronchoscopy were significantly associated with post-bronchoscopy adverse events ($p=0.001$). Adverse events occurred in 33.3% of patients with normal oxygen saturation, increased to 88.5% among those with mild-to-moderate hypoxemia, and occurred in all patients with severe or life-threatening hypoxemia. Patients who developed desaturation during bronchoscopy also had a higher frequency of adverse events than those without desaturation ($p<0.001$). This finding supports the study by Darie et al., which reported that desaturation during bronchoscopy was associated with an increased risk of respiratory compromise and post-procedural complications [24]. Continuous oxygen saturation monitoring is therefore essential for the early detection of hypoxemia and timely intervention. Pre- and post-bronchoscopy FiO_2 were not significantly associated with post-bronchoscopy adverse events ($p=0.491$ and $p=0.502$, respectively). A high FiO_2 may reflect the severity of respiratory impairment or an effort to optimize oxygenation rather than a direct cause of adverse events. Bronchoscopy-related complications are multifactorial and may also be influenced by underlying pulmonary disease, the severity of hypoxemia, procedure duration, BAL volume, secretion burden, positive end-expiratory pressure, ventilator response, hemodynamic status, and overall disease severity [25]. Increasing FiO_2 and adjusting ventilator settings before and during bronchoscopy are also strategies used to prevent desaturation in mechanically ventilated patients [23]. Thus, although FiO_2 remains clinically important, it should be interpreted together with other oxygenation and ventilation parameters.

The most common microbiological finding was *Acinetobacter baumannii* (28.3%), followed by *Pseudomonas aeruginosa* (21.7%) and *Klebsiella pneumoniae* ssp. *pneumoniae* (15.2%). The predominance of gram-negative bacteria is consistent with the pattern of infection among ICU patients, particularly those with severe pneumonia, hospital-acquired pneumonia, ventilator-associated pneumonia, mechanical ventilation, previous antibiotic exposure, and invasive procedures. BAL remains valuable for identifying causative microorganisms and guiding appropriate antimicrobial therapy [26,27]. Bacterial growth was not significantly associated with post-bronchoscopy adverse events ($p=0.460$). Adverse events occurred in 23 of 36 patients (63.9%) with bacterial growth and in 8 of 10 patients (80.0%) without bacterial growth. These findings suggest that microbiological results primarily reflect the etiology of the underlying pulmonary disease rather than a direct mechanism of post-bronchoscopy adverse events, which are more likely to be influenced by baseline respiratory status, mechanical ventilation, secretion retention, suction, BAL, sedation, and changes in oxygen saturation during the procedure. In the multivariable analysis, the converged logistic regression model was not statistically significant overall (Omnibus $p=0.100$; Nagelkerke $R^2=0.288$). Although educational attainment was significant in the partial analysis, this finding should be interpreted cautiously because the overall model was not significant. Therefore, this study did not identify an independent factor that consistently predicted post-bronchoscopy adverse events. This study has several limitations. Its cross-sectional design precludes causal inference, and the single-center setting with a modest sample size may limit statistical power and the generalizability of the findings—factors that likely contributed to the non-significant overall regression model. Oxygen saturation was assessed by pulse oximetry rather than arterial blood gas analysis, and procedural variables such as sedation depth and procedure duration were not fully controlled. Larger

multicenter prospective studies are warranted to confirm these associations and to identify independent predictors of post-bronchoscopy adverse events in critically ill patients.

CONCLUSION

Oxygen saturation levels and desaturation during bronchoscopy were significantly associated with post-bronchoscopy adverse events among patients in the ICU at H. Adam Malik General Hospital. Patients with lower oxygen saturation during the procedure had a higher frequency of adverse events. In contrast, pre- and post-bronchoscopy oxygen saturation, FiO₂ before, during, and after bronchoscopy, and bacterial growth were not significantly associated with post-bronchoscopy adverse events. Decreases in oxygen saturation during the procedure should be anticipated through close oxygenation monitoring before, during, and after bronchoscopy.

DECLARATIONS

None

CONSENT FOR PUBLICATION

The Authors agree to be published in the Journal of Society Medicine.

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COMPETING INTERESTS

The authors declare no conflicts of interest in this case report.

AUTHORS' CONTRIBUTIONS

MMH conceived and designed the study, performed data acquisition and statistical analysis, interpreted the data, and drafted the manuscript. SB contributed to the study conception and design, provided clinical supervision, and critically revised the manuscript for its important intellectual content. E contributed to the study design, supervised data collection and interpretation, and critically reviewed the manuscript. All authors have read and approved the final version of the manuscript and agree to be held accountable for all aspects of the work.

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