*Osmangazi Journal of Med, 2025;47(6):982-989*
*DOI: 10.20515/otd.1753340*

*Research Article*
*Araştırma Makalesi*

**Osmangazi Journal of Medicine**
**e-ISSN: 2587-1579**

# Bronchoscopy in the Respiratory Intensive Care Unit: A 4-Year Review

Solunum Yoğun Bakım Ünitesinde Bronkoskopi: 4 Yıllık Değerlendirme

Pervin Hanci[1], Berfin Karadaş[2], Ethem Yildiz[2], Erhan Tabakoğlu[1]

[1]Trakya Üniversitesi Tıp Fakültesi, Göğüs Hastalıkları Anabilim Dalı, Yoğun Bakım Bilim Dalı, Edirne, Türkiye.
[2]Trakya Üniversitesi Tıp Fakültesi, Göğüs Hastalıkları Anabilim Dalı, Edirne, Türkiye.

***ORCID ID of the authors***
PH. 0000-0002-7207-2041
B.K. 0009-0006-2361-8980
EY. 0000-0002-4433-4278
ET. 0000-0003-1315-4538

**Correspondence / Sorumlu yazar:**
Pervin HANCI

Trakya Üniversitesi Tıp Fakültesi, Göğüs Hastalıkları Anabilim Dalı, Yoğun Bakım Bilim Dalı, Edirne, Türkiye.

**e-mail:** pervinhanci@trakya.edu.tr

**Ethics Committee Approval:** The study was approved by Trakya University Noninterventional Clinical Research Ethical Committee (Decision no: TUTF-GÖBAEK 2024/602-01/38, Date: 06.01.2025)
**Informed Consent:** The authors declared that it was not considered necessary to get consent from the patients because the study was a retrospective data analysis.
**Authorship Contributions:** P.H. and E.Y.searched the literature. P.H., E.Y., and E. T. designed the study. B.K. performed the data abstraction and assessed data entry. P.H.performed the statistical analysis. P.H., B. K. and E.Y. prepared the manuscript and drafted the article. All authors interpreted the data. P.H. takes full responsibility for the work as a whole, including the study design, access to data, and the decision to submit and publish the manuscript. All authors approved this manuscript in its final form

**Copyright Transfer Form:** Copyright Transfer Formwas signed by all authors.

**Conflict of Interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**Received** : 23.07.2025
**Accepted** 04.09.2025
**Published** :08.09.2025

**Abstract:** Bronchoscopy is a valuable diagnostic and therapeutic procedure in intensive care units (ICUs), but real-world data regarding its application and safety in critically ill patients remain limited. This study aimed to evaluate the indications, findings, complications, and microbiological outcomes of bronchoscopy in an ICU setting. This retrospective study included 152 ICU patients who underwent 227 bronchoscopy procedures between July 2020 and November 2024. Demographic characteristics, procedural indications, oxygen support modalities, microbiological results, and complication rates were recorded. The median age of patients was 68 [IQR: 59–75] years, and 64.5% were male. Bronchoscopy was most frequently performed for the clearance of secretions and the treatment of atelectasis. Complete or partial resolution of atelectasis was achieved in 92.6% of such cases. Infectious pathogens were identified in 34.8% of all procedures. The most common complication was hypoxemia (12.8%), followed by arrhythmias (3.1%) and hemodynamic instability (1.8%). No serious adverse events were reported. No statistically significant difference in complication rates was observed between oxygen support groups. Bronchoscopy is a safe and effective tool for both diagnostic and therapeutic purposes in ICU patients when performed by experienced teams. Careful patient selection and appropriate oxygenation strategies are critical to minimise complications, especially hypoxemia.
**Keywords:** Bronchoscopy, Intensive Care Unit, Oxygen inhalation therapy

**Özet:** Bronkoskopi, yoğun bakım ünitelerinde (YBÜ) değerli bir tanı ve tedavi prosedürüdür, ancak kritik hastalarda uygulanması ve güvenliği ile ilgili gerçek dünya verileri sınırlıdır. Bu çalışma, YBÜ ortamında bronkoskopinin endikasyonlarını, bulgularını, komplikasyonlarını ve mikrobiyolojik sonuçlarını değerlendirmek amacıyla yapılmıştır. Bu retrospektif çalışmaya, Temmuz 2020 ile Kasım 2024 arasında 227 bronkoskopi prosedürü uygulanan 152 YBÜ hastası dahil edildi. Demografik özellikler, prosedür endikasyonları, oksijen desteği yöntemleri, mikrobiyolojik sonuçlar ve komplikasyon oranları kaydedildi. Hastaların medyan yaşı 68 [IQR: 59–75] yıl idi ve %64,5'i erkekti. Bronkoskopi en sık sekresyonların temizlenmesi ve atelektazinin tedavisi için uygulandı. Bu vakaların %92,6'sında atelektazinin tamamen veya kısmen düzelmesi sağlandı. Tüm prosedürlerin %34,8'inde enfeksiyöz patojenler tespit edildi. En sık görülen komplikasyon hipoksemi (%12,8) idi, bunu aritmiler (%3,1) ve hemodinamik instabilite (%1,8) izledi. Ciddi advers olaylar bildirilmedi. Oksijen destek grupları arasında komplikasyon oranlarında istatistiksel olarak anlamlı bir fark gözlenmedi. Bronkoskopi, deneyimli ekipler tarafından uygulandığında yoğun bakım hastalarında hem tanı hem de tedavi amaçlı güvenli ve etkili bir araçtır. Komplikasyonları, özellikle hipoksemiyi en aza indirmek için dikkatli hasta seçimi ve uygun oksijenasyon stratejileri çok önemlidir.
**Anahtar Kelimeler:** Bronkoskopi, Yoğun Bakım Ünitesi, Oksijen inhalasyon tedavisi

**How to cite/ Atıf için:** Hanci P, Karadaş B, Yildiz E, Tabakoğlu E. Bronchoscopy in the Respiratory Intensive Care Unit: A 4-Year Review, Osmangazi Journal of Medicine, 2025;47(6):982-989

## 1. Introduction

Bronchoscopy is a vital and versatile tool that enables both diagnostic and therapeutic interventions in critically ill patients in modern intensive care units (ICUs). Since its initial use in the late 19th century for removing foreign bodies, the scope of bronchoscopy has expanded significantly due to technological advancements and a deeper understanding of respiratory pathophysiology [1, 2]. In the ICU, where respiratory complications and invasive mechanical ventilation are common, bronchoscopy provides unique advantages by facilitating real-time visualisation and targeted management of airway and pulmonary conditions. Diagnostic uses of bronchoscopy in the ICU include evaluating pneumonia, haemoptysis, and airway obstruction, as well as collecting specimens for microbiological or pathological analysis [1, 3, 4]. In immunocompromised patients or those with atypical infections, bronchoalveolar lavage (BAL) is often essential for identifying the causative pathogens and guiding appropriate antimicrobial therapy [5]. It is also advantageous in differentiating conditions that mimic infectious pneumonia, such as organizing pneumonia, acute eosinophilic pneumonia, alveolar hemorrhage, leukocytosis, or acute lupus pneumonia [6, 7]. Bronchoscopy is essential in managing complications that can arise from mechanical ventilation, such as atelectasis caused by mucus plugs and suspected ventilator-associated pneumonia (VAP). It is commonly used to remove mucus plugs, expectorated or aspirated materials, manage severe bleeding (massive haemoptysis), and assess or dilate areas of airway obstruction. Additionally, bronchoscopy is crucial for managing difficult airways, performing percutaneous tracheostomies, and assessing airways after extubation. These functions underscore the vital role of bronchoscopy in addressing not only acute respiratory emergencies but also in enhancing long-term outcomes for patients in the ICU.

While bronchoscopy is generally regarded as a safe procedure, its use in the ICU necessitates specialised expertise. ICU patients are often hemodynamically unstable and frequently require mechanical ventilation, high levels of oxygen supplementation, or inotropic agents. These factors place patients at a higher risk for complications during bronchoscopy, including hypoxemia, hypercapnia, hypotension, arrhythmias, or barotrauma. Therefore, successful implementation of bronchoscopy in the ICU demands not only technical competence but also effective multidisciplinary coordination, appropriate patient selection, and a thorough understanding of ventilatory physiology and patient monitoring. Despite its clinical relevance, the literature on bronchoscopy in the ICU is relatively limited, particularly in terms of prospective or structured retrospective data from real-world settings. Much of the available evidence is based on small case series or expert consensus, and variation in institutional practice is considerable. Therefore, descriptive studies based on actual clinical practice are crucial for better defining the indications, procedural characteristics, and outcomes associated with bronchoscopy in the ICU.

This study presents a descriptive observational analysis of bronchoscopy procedures conducted in our ICU. Our objective is to evaluate the characteristics of the patient population, the indications for the procedure, the techniques employed, and both the diagnostic and therapeutic outcomes. By sharing our institutional experiences, we aim to enhance the understanding of bronchoscopy's role in critically ill patients and provide practical guidance for clinicians looking to optimise bronchoscopic interventions in the intensive care setting.

## 2. Materials and Methods

In our retrospective study, the data of patients hospitalised in Trakya University Respiratory Intensive Care Units between July 1, 2020, and November 1, 2024, were examined. Patients whose data could not be retrieved were excluded from the study. Approval for the study was obtained from Trakya University Faculty of Medicine Non-Interventional Scientific Research Ethics Committee (TUTF-GÖBAEK 2024/602-01/38). Upon admission to the clinic, patients or their legally authorized relatives provided written informed consent for the processing and publication of their medical records (with names disclosed) for scientific purposes in line with the clinic's regulatory procedures.

The bronchoscopy procedures were performed using a FUJIFILM Corporation/EB-530S bronchoscope, Japan. In our ICU, the procedure was avoided if any contraindications were identified. These contraindications include severe hypoxemia, hemodynamic instability despite the administration of vasoactive drugs, acute cardiac ischemia, and uncontrolled cardiac arrhythmias. For patients undergoing FOB while on non-invasive ventilation (NIV), invasive mechanical ventilation (IMV), and high-flow nasal cannula (HFNC) therapy, the inspiratory oxygen fraction ($FiO_2$) is increased to 100% for 10 minutes before the procedure. During IMV and NIV, a catheter mouthpiece is placed on the endotracheal tube or NIV interface. Ventilation and oxygen support are maintained throughout the procedure without disconnecting from the mechanical ventilator. In patients undergoing HFNC, the flow rate was increased to 50 L/min; the procedure was performed orally by wearing a mouthpiece. In patients undergoing conventional oxygen therapy (COT), the procedure was performed either nasally or orally under a diffusing mask, with an oxygen flow of 10 L/min administered before and during the procedure. The procedure was terminated in case of severe hypoxemia ($SpO_2$ < 88%), refractory hypotension, new onset of severe arrhythmia, uncontrolled bleeding, deterioration in ventilator parameters, or any other complication threatening patient hemodynamic stability.

Information on patients who underwent bronchoscopy was obtained from our hospital's electronic medical records system. Age, gender, ICU admission diagnosis, bronchoscopy indications, oxygen support therapy administered during procedure (diffuser mask oxygen therapy, HFNC, NIV, IMV), microorganisms isolated from bronchial lavage or BAL, procedure-related complications, duration of intensive care unit stay, and outcomes were recorded. The study was conducted by the principles outlined in the Declaration of Helsinki.

Demographic and clinical data, descriptive statistics, and quantitative data were expressed as median [25th-75th percentile] to illustrate the relationship between categorical data. Qualitative data were expressed as numbers and percentages (%). The Fisher's exact test was used to evaluate the relationship between complications that developed during the procedure and the type of oxygen support therapy used during bronchoscopy. A p-value <0.05 was considered significant. SPSS program version 22 (IBM Corp., Armonk, NY, USA) was used for calculations.

## 3. Results

Our study included 152 patients who were admitted to the ICU between July 1, 2020, and November 1, 2024, and underwent bronchoscopy at least once during their hospitalisation. Characteristics and ICU outcomes of the patients are shown in Table 1. The median age of the patients was 68 [59-75] years, and 64.5% were male. The main reasons for ICU admission were respiratory failure (55.9%), shock (20.4%), and cerebrovascular disease (12.3%). A total of 227 procedures were performed in these patients. Indications for bronchoscopy are presented in Figure 1. Secretion clearance and atelectasis were the most common indications for bronchoscopy. Complete patency was achieved in 32 (55.1%) and partial patency in 21 (37.5%) of 56 procedures performed with the indication of atelectasis. In 3 procedures, no post-procedural change in atelectasis was observed. In 3 cases, airway patency could be achieved with cryo procedure in addition to bronchoscopic aspiration. IMV was used in 170 (74.8%), NIV in 10 (4.4%), HFNC in 27 (11.8%), and oxygen therapy via a diffusing mask in 20 (8.8%) of the procedures.

Infectious pathogens were detected in 79 (34.8%) of the samples collected across all procedures. The frequency of microbiologic agents is shown in Table 2. Lower respiratory tract infections (LRTI) were present in 101 patients (66.4%) before the procedure, and these patients underwent bronchoscopy a total of 147 times. In 44 of these patients (43.5%), microbiologic pathogens were detected, and agent-directed treatment was initiated. The mortality rate was 22.7% (n=10) in patients in whom agent-directed treatment was initiated and 33.3% (n=19) in patients in whom the agent could not be identified (p=0.24). A microbiologic agent was detected in 8 (15%) of 51 patients in whom LRTI was not considered clinically.

Complications associated with bronchoscopy, according to the oxygen support methods, are shown in Table 3 and Figure 2. In 227 procedures, hypoxemia was observed in 12.8% (n=29), arrhythmia in 3.1% (n=7), hemodynamic disturbance in 1.8% (n=5), and bronchospasm in 0.5% (n=1). Hypoxemia was most frequently observed in procedures performed during COT (30%). However, when different oxygen support methods were compared in terms of the development of hypoxemia, no statistically significant difference was found (p=0.10). Similarly, there were no significant differences in the rates of arrhythmia (p=0.89), bronchospasm (p=0.95), and hemodynamic deterioration (p=0.77) between the oxygen support groups. All complications were mild, and no serious adverse events requiring additional intervention were observed.

**Table 1.** Characteristics and ICU outcomes of the patients

| Characteristics | N=152 |
|---|---|
| Age (years) | 68 [59-75] |
| Gender (male)* | 98 (64.5) |
| ICU admission diagnosis* | |
| *Respiratory failure* | 85 (55.9) |
| *Cerebrovascular diseases* | 19 (12.3) |
| *Shock* | 31 (20.4) |
| *Postoperative* | 9 (5.9) |
| *Trauma* | 2 (1.3) |
| *Multiorgan failure* | 3 (2) |
| *Intoxication* | 1 (0.7) |
| ICU length of stay (days) | 23 [13-40] |
| Hospital mortality* | 46 (30.3) |

*Definition of abbreviations: ICU: Intensive Care Unit. Data expressed as median [$25^{th}$-$75^{th}$ percentile] and *: n(%).*

**Table 2.** Pathogens isolated from bronchoscopic samples

| Name of the pathogen | N(%) |
|---|---|
| *Acinetobacter baumannii* | 26 (11.5) |
| *Pseudomonas aeruginosa* | 24 (10.6) |
| *Klebsiella pneumoniae* | 16 (7) |
| *Stenotrophomonas maltophilia* | 6 (2.6) |
| *Candida albicans* | 3 (1.3) |
| *Aspergillus fumigatus* | 2 (0.9) |
| *Enterobacter aerogenes* | 2 (0.9) |
| *Escherichia coli* | 2 (0.9) |
| *Mycobacterium tuberculosis* | 1 (0.4) |
| *Burkholderia cepacia* | 1(0.4) |

**Table 3:** Bronchoscopy complications according to the oxygen support methods

| Complication | Total (n=227) | IMV (n=170) | NIV (n=10) | HFNC (n=27) | COT (n=20) | p |
|---|---|---|---|---|---|---|
| Hypoxemia | 29 | 20 (11.8) | 1 (10) | 2 (7.4) | 6 (30) | 0.10 |
| Arrhythmia | 7 | 5 (2.9) | 0 (0) | 1 (3.7) | 1 (5) | 0.89 |
| Hemodynamic compromise | 5 | 3 (1.8) | 0 (0) | 1 (3.7) | 0 (0) | 0.77 |
| Bronchospasm | 1 | 1 (0.6) | 0 (0) | 0 (0) | 0 (0) | 0.95 |

*Definitions of abbreviations: IMV: Invasive mechanical ventilation, NIV: Noninvasive ventilation, HFNC: High flow nasal cannula, COT: Conventional oxygen therapy. Data expressed as n (%).*

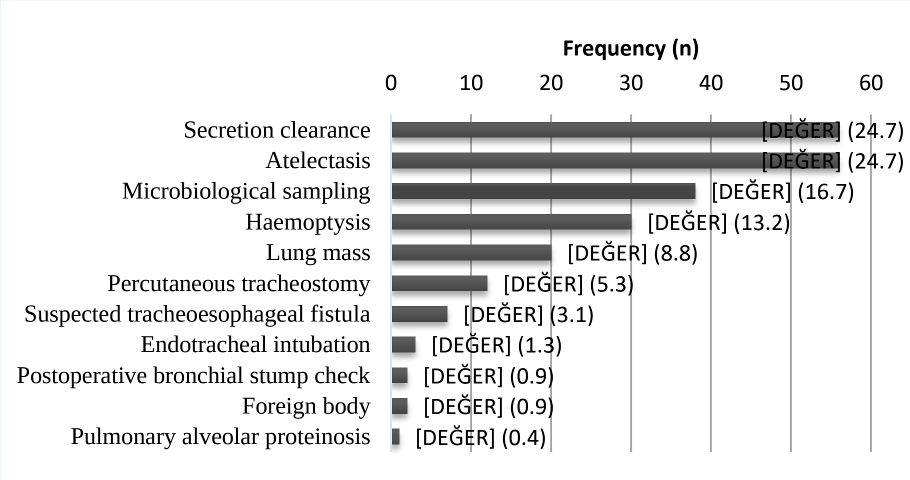


***Figure 1.*** *Bronchoscopy indications*

*Definitions of abbreviations: Data expressed as n (%).*

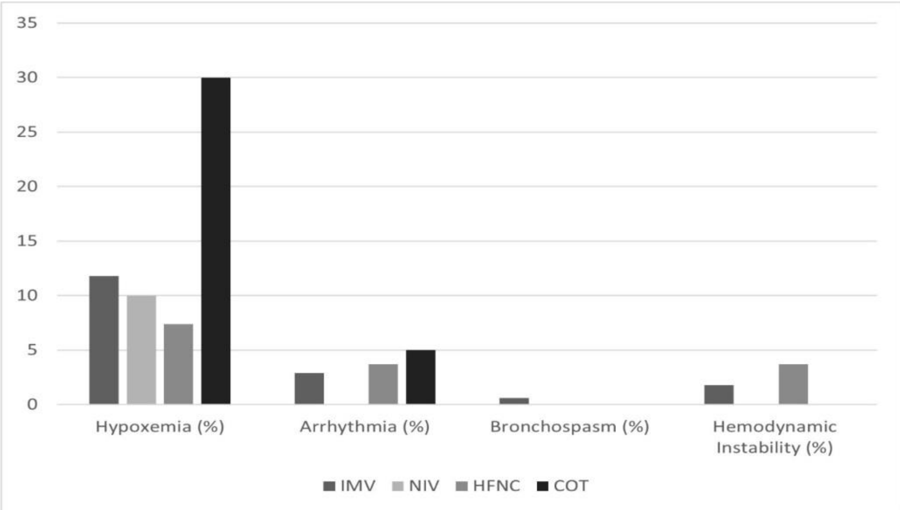


***Figure 2.*** *Bronchoscopy complications according to the oxygen support methods*

Definitions of abbreviations: IMV: Invasive mechanical ventilation, NIV: Noninvasive ventilation, HFNC: High flow nasal cannula, COT: Conventional oxygen therapy. Data expressed as a percentage.

## 4. Discussion

In this study, data from 227 procedures performed on 152 patients admitted to the ICU and who underwent bronchoscopy were evaluated. Bronchoscopy was most frequently performed for secretion clearance and atelectasis indications, and significant airway patency was achieved in cases of atelectasis. When evaluating complications, hypoxemia was the most common complication, followed by arrhythmia, hemodynamic instability, and bronchospasm. All complications were mild, and no serious adverse events were observed. No significant difference was noted among supportive methods in terms of complications.

Bronchoscopy is an important tool for pulmonologists and intensivists to diagnose and treat various pulmonary conditions. In the ICU, due to its safety and portability, bronchoscopy plays a significant role in diagnosis and treatment for critically ill patients who cannot be transferred to remote imaging or diagnostic units [8]. Its applications range from investigating haemoptysis and unexplained pulmonary infiltrates to assessing airway injuries related to trauma or smoke inhalation. Bronchoscopy is particularly advantageous for microbiological sampling in ventilator-associated pneumonia (VAP) and immunocompromised patients, as it enables rapid and accurate identification of pathogens, which can guide targeted antimicrobial therapy [9]. Furthermore, bronchoscopy is essential for managing airway obstructions by removing mucus plugs and foreign bodies, as well as addressing complications related to endotracheal tubes, such as obstruction or malposition. Bronchoscopy is also used therapeutically in procedures like bronchial stent placement and endobronchial interventions for controlling bleeding (e.g., through argon plasma coagulation or cryotherapy). Additionally, it serves as a safety measure during percutaneous tracheostomy procedures [10].

Bronchoscopy has been proven highly effective in improving respiratory function for patients with atelectasis. Numerous studies have demonstrated significant enhancements in oxygenation parameters. For instance, a randomised controlled study by Megahed et al. found that the hypoxic index increased from 278.5±90.3 to 343.2±100.8 within seven days after the intervention [11]. Similarly, Adolf et al. reported a marked increase in arterial oxygen pressure, rising from 58.9 mmHg to 70.9 mmHg, along with a decrease in shunt fraction from 23.9% to 15% [12]. Various studies indicate that a considerable percentage of cases (47-75%) experienced resolution of atelectasis, with early intervention consistently linked to quicker and more complete recovery [13-16]. In our study, complete reopening was achieved in 55.1% of atelectasis cases, while partial reopening occurred in 37.5%, aligning with the therapeutic success rates noted in previous research.

Bronchoscopy is becoming increasingly important for intensive care patients receiving mechanical ventilation. It serves not only as a diagnostic and therapeutic tool but also as a procedure that can potentially improve clinical outcomes. Numerous studies have demonstrated that the early and appropriate use of bronchoscopy can enhance diagnostic accuracy, optimise antimicrobial therapy, and positively affect patient outcomes. For instance, Megahed et al. discovered that early bronchoscopy in patients with aspiration pneumonia improved the Clinical Pulmonary Infection Score, reduced mortality, and shortened the duration of mechanical ventilation [11]. Similarly, Heyland et al. reported that diagnostic bronchoscopy decreased the use of empirical broad-spectrum antibiotics, increased diagnostic reliability, and lowered ICU mortality rates from 34.7% to 18.5% [17]**.** Solé Violán et al. documented a significant narrowing of antibiotic regimens following bronchoscopy-guided sampling, highlighting its role in antimicrobial management [18].

In cases of therapeutic bronchoscopy, improvements were observed in Sequential Organ Failure Assessment (SOFA) scores, earlier weaning from mechanical ventilation, and shorter ICU stays [19]. However, outcomes can vary based on patient selection and the specific type of bronchoscopy performed. For example, Zhang et al. found that patients treated with bronchoscopy had significantly lower risks of ICU and in-hospital mortality, with risk ratios of 0.33 and 0.40, respectively [20]. Guidry et al. noted shorter hospital stays for patients after diagnostic bronchoscopy but longer stays following therapeutic interventions [21]. Verma et al. reported that 75% of patients who underwent bronchoscopy were quickly weaned from mechanical ventilation and transferred to the ward within an average of two days [22]. In our study, microbiological pathogens were detected in 43.5% of patients suspected of having LRTI before bronchoscopy, leading to the initiation of targeted treatment. Patients who received this targeted therapy exhibited lower mortality rates (22.7% vs. 33.3%), although this difference was not statistically significant. This suggests that bronchoscopy-guided sampling can be an effective tool for optimising antimicrobial therapy, but its impact on mortality should be evaluated in larger studies.

Bronchoscopy, when performed by trained professionals, is characterised by low complication and mortality rates [6]. Risks associated with sedation include respiratory depression, arrhythmias, and hypotension, while procedure-related complications such as hypoxemia, bronchospasm, and bleeding are more common in critically ill patients or those with thrombocytopenia [10]. Especially in patients under mechanical ventilation, the risk of pneumothorax is high, so measures such as oxygen support, shortening the procedure duration, and post-biopsy monitoring should be taken. Recent systematic reviews emphasise that careful patient selection is necessary to balance the potential benefits of bronchoscopy against the risks of hypoxemia and hemodynamic instability in intensive care settings [20, 23]. In our study, patients under mechanical ventilation comprised the majority of bronchoscopy procedures (74.8%), and the procedure was safely performed across all support methods in this group without any serious adverse events.

The oxygen support method selected during the procedure is also important in terms of reducing the risk of hypoxemia. At this point, the choice of oxygen support method to be applied during bronchoscopy plays a critical role in managing the risk of hypoxemia. The effectiveness of different oxygen support methods during bronchoscopy in hypoxemic patients has been investigated in various studies. HFNC has demonstrated advantages over COT in patients with mild to moderate acute respiratory failure undergoing bronchoscopy, improving oxygen saturation and reducing desaturation events [24, 25]. In a recent observational study, it was found that HFNC is associated with less decrease in SpO2 levels during FOB in acute care patients compared to COT [26]. However, for patients with more severe hypoxemic acute respiratory failure or heart failure, continuous positive airway pressure (CPAP) or NIV may be preferred [24, 25]. Simon et al. demonstrated that NIV is superior to HFNC in terms of oxygenation during and after bronchoscopy in patients with moderate to severe hypoxemia [27]. In our study, we observed the highest rate of hypoxemia during COT. However, we found no statistically significant difference in the frequency of hypoxemia across different oxygen support methods. These findings suggest that the optimal oxygenation strategy during bronchoscopy should be tailored to the patient's characteristics and the specific clinical scenario. While the use of NIV is recommended for patients with severe hypoxemia, HFNC may be a suitable alternative for those with mild to moderate hypoxemia who do not require intubation. Additionally, the effectiveness and safety of both methods largely depend on the operator's experience and the implementation of appropriate sedation protocols.

This study has some limitations. First, because it is a single-center and retrospective design, the generalizability of the findings is limited. Retrospective data analysis, which depends on patient selection and the completeness of records, may be subject to observational biases due to missing information or recording errors. Second, the identification and grading of complications related to bronchoscopy procedures depend on the accuracy of the records in patient files. This may lead to underreporting of complication rates, especially if minor complications are not adequately documented. Third, the imbalance in the number of cases between oxygen support groups limited the statistical power of the analysis. Due to the low number of procedures in the COT and NIV groups, the statistical significance of differences in complication rates could not be fully assessed. In some groups with low observation counts, Fisher’s exact test was applied, but this reduced the statistical power. Finally, although clinical outcomes such as mortality and treatment response were analysed, long-term outcomes after bronchoscopy (e.g., ICU stay duration, ventilator duration) were not evaluated. Therefore, it is not possible to comment on the long-term clinical benefits of bronchoscopy.

In conclusion, the findings of our study emphasise the importance of bronchoscopy as a diagnostic and therapeutic aid in intensive care patients receiving mechanical ventilation, highlighting its role in patient-specific treatment management and potentially improved outcomes. Bronchoscopy is a safe method for both diagnosis and treatment in intensive care patients. The complication rates are low, and safety can be further enhanced through proper patient selection, optimisation of supportive therapies, and experienced teams. Careful selection of supportive methods, such as HFNC and NIV, according to the patient's condition, is especially recommended to manage the risk of hypoxemia.

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