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Clinical outcomes of rigid bronchoscopic airway interventions: insights from an Indian tertiary care center

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Abstract

Rigid bronchoscopy (RB) forms an indispensable part of the interventional bronchoscopist's skills, allowing the performance of complex airway interventions for a variety of benign and malignant airway disorders. Experiential data on the procedure is limited, particularly in adults. We conducted a retrospective analysis of medical records from 82 adult patients who underwent RB at our center. The primary objective was to evaluate the clinical indications, procedural outcomes, complication rates, and overall efficacy of RB in this cohort. Collected data included patient demographics, presenting symptoms, etiological diagnoses, and anesthesia-related parameters such as induction agents, maintenance protocols, sedation strategies, and the use of neuromuscular blockade. Post-procedural outcomes and follow-up mortality were also assessed.

The mean patient age was 56.2±12.6 years, with 71.9% males. Common symptoms were cough (90.2%) and dyspnea (82.9%). Malignancies accounted for 90.2% of cases, with lung cancer being the most prevalent (68.2%). RB was primarily performed for stenting (63.4%) and tumor debulking (29.2%). Total intravenous anesthesia was used in 92.6%, with mean induction and reversal times of 75.3±4.3 seconds and 10.69±2.4 minutes, respectively. Minor complications occurred in 29.3% (bleeding 29.3%, bronchospasm 17.1%, and hypoxia 13.4%) and major complications in 2.4%. After the procedure, immediate extubation was achieved in 49 patients (59.8%), while 24 (29.3%) required short-term ventilator support (<24 h) and 9 (11.0%) required prolonged support (>24 h). The median hospital stay was 7 days (interquartile range 5-11). Symptomatic improvement at discharge was observed in 72/82 patients (87.8%). In-hospital mortality was 6.1% (5/82), mainly due to severe infections (hospital-acquired or ventilator-associated pneumonia) or massive endobronchial bleeding. Among patients with available follow-up (n=52), 3-month mortality was 11.5% (n=6).

In this real-world cohort, RB demonstrated a high success rate with minimal complications, reinforcing its role as a critical tool in managing complex airway conditions. The procedure demonstrated high efficacy, particularly in malignant cases, with acceptable complication rates. Dedicated training is essential to enhance experience, gain expertise, and ensure optimal outcomes while minimizing procedural risks.

Key words: airway interventions, central airway obstruction, interventional pulmonology, lung cancer, rigid bronchoscopy.

Introduction

Rigid Bronchoscopy (RB) is a critical intervention in the management of various airway conditions, particularly in patients with malignant airway obstruction and benign strictures. Originally developed for foreign body removal, the technique has evolved to include a range of therapeutic procedures such as tumor debulking, stent placement and dilation of stenosis [1]. In tertiary care settings where patients often present with complex and advanced diseases, RB serves as an important tool in both diagnostic and therapeutic airway procedures [2].

Central airway obstruction (CAO) is a life-threatening respiratory emergency demanding immediate intervention and is one of the commonest indications for performing RB. Malignant CAO is a significant complication in patients with thoracic malignancies, particularly advanced lung cancer, which remains the leading cause of cancer-related deaths worldwide [3]. The use of RB in managing malignant CAO has emerged as a significant palliative measure that offers immediate relief of symptoms and improves the patient's quality of life. In recent years, advancements in endoscopic techniques have expanded the indications for RB, allowing for more sophisticated interventions such as laser treatment, cryotherapy and airway stenting [4]. In benign conditions, RB is indispensable in managing post-intubation tracheal stenosis (PITS) and tracheoesophageal fistulae, which often require dilation and/or stenting for long-term relief [5].

Despite its benefits, RB is not without risks. Complications such as bleeding, hypoxia and bronchospasm are reported in the literature, and their management requires a skilled multidisciplinary team [6-8]. We present our emerging experience with RB in a tertiary care referral centre, with the aim to highlight the procedural indications, outcomes and complications in a challenging patient cohort.

Materials and Methods

Ethical approval

The study was approved by the Institutional Ethics Committee of the All India Institute of Medical Sciences, Rishikesh, India (approval no. AIIMS/IEC/24/575 dated October 11, 2024). The need for written informed consent was waived in view of the use of anonymous records and retrospective nature of data collection and analysis. The study was conducted in accordance with the Declaration of Helsinki's ethical principles for medical research involving human subjects.

Study design, settings, subjects and data collection

This retrospective observational study was done at a tertiary teaching medical center of Northern (sub-Himalayan) India. All adult patients who had undergone rigid bronchoscopic airway interventions between February 2021 to June 2024 were included. Medical records of these subjects were reviewed in detail to extract information on demographics, presenting symptoms, underlying etiological condition (malignant or benign), anesthesia and procedural details. Post-procedural outcomes and follow-up mortality were also assessed. The main objective was to analyze the clinical indications, outcome, complications and overall efficacy of the rigid bronchoscopic airway interventions performed.

Statistical analysis

Data was entered into a Microsoft Excel sheet and analyzed using SPSS, version 26.0. Descriptive statistics for quantitative variables were presented as mean ± standard deviation (SD) for normally distributed continuous data and median with interquartile range (IQR) for non-normally distributed data. Normality of data distribution was assessed using the Shapiro–Wilk test. Categorical variables were expressed as frequencies and percentages. The level of statistical significance was 5% ($p<0.05$).

Results

Eighty-two patients underwent rigid bronchoscopic airway interventions during the study period. The mean age of participants was 56.2±12.6 years. Males comprised 59 (71.9%) cases while there were 23 (28.1%) females. The most common presenting symptoms were cough (90.2%) and dyspnea (82.93%). Around 18.2% (n=15) patients had stridor on presentation, indicating significant central airway involvement. A total of 74 (90.2%) individuals were diagnosed with a malignant underlying condition with lung cancer being the commonest, impacting 56 (68.2%) individuals. Among the lung cancer cases, squamous cell carcinoma was the predominant histological subtype (n=40, 71.1%), followed by adenocarcinoma (n=9, 16.3%) and small cell lung cancer/carcinoid (n=7, 12.6%). In case of esophageal malignancies (n=13, 15.8%) the most common histopathology was squamous cell carcinoma (n=12, 92%). Eight (9.8%) patients exhibited a benign etiology. Most patients had a poor performance status at baseline (ECOG score 2 in 82.2%). The demographic details, symptoms at clinical presentation and underlying etiological conditions are depicted in Table 1.

RB was primarily performed for stent placement (52 cases [63.41%]), tumor debulking (24 cases [29.2%]), balloon dilatation (13 cases [15.8%]) and high-risk biopsy (10 cases [12.1%]). Common anatomical indications included bronchial growth (21 cases [25.6%]), tracheal growth (18 cases [21.9%]), and tracheal compression (16 cases [19.5%]). The indications for performing RB are presented in detail in Table 2.

The median time for vocal cord visualization was 32±14 seconds, and for tracheal intubation 38±14 seconds. The mean total procedural duration was 62.8±14.8 minutes. Stenting was the predominant intervention performed in 52 patients (63.4%). Tumor debulking and associated techniques were used in 24 (29.3%). RB procedural details and interventional techniques employed are shown in Table 3.

Complications were encountered in 29.3% (n=24) of cases. The majority were minor and effectively managed using standard protocols, with only 5 patients (6%) requiring escalation of care and prolonged ICU stay. The most frequently observed complication was mild-to-moderate airway bleeding seen in 24 cases (29.3%), followed by bronchospasm in 14 cases (17.1%), and hypoxia in 11 cases (13.4%). Life threatening complications occurred in 2.4% (n=2) of patients, comprising one case each of severe endobronchial bleeding and hypoxia-induced arrhythmia. No traumatic injury to the lips, teeth, or vocal cords were reported. Importantly, the majority of complications were non-serious and were successfully managed without significant morbidity, showing the overall safety and feasibility of RB when performed in a well-trained, adequately-equipped setting. A detailed summary of procedural complications is provided in Table 4.

All procedures were performed under general anesthesia. Induction was achieved mainly with intravenous (IV) administration of propofol, succinylcholine and fentanyl. Following rigid bronchoscope intubation, maintenance of anesthesia was ensured using inhalational agents with intermittent IV boluses of sedation. Inj. vecuronium was used where prolonged relaxation was required. Reversal of neuromuscular blockade was achieved using IV neostigmine and glycopyrrolate where required. Total intravenous anesthesia was used in 76 cases (92.6%), while a combination of inhaled and IV anesthesia was used in 6 cases (7.3%).

Anesthesia-related complications were minimal, with no significant adverse events noted. Transient hypotension and bradycardia were observed in two cases (2.4%) and managed effectively with fluid resuscitation and vasoactive support. The mean induction time was 62.8 ± 14.8 seconds and reversal time was 10.69 ± 2.4 minutes (Table 4).

Post-procedural clinical outcomes were evaluated in terms of symptomatic improvement, extubation timelines, duration of ventilatory support, hospital stay, oxygen requirement at

discharge, and in-hospital mortality. Overall, symptomatic improvement at discharge was observed in 72 patients (87.8%). Improvement with benign airway disease, occurring in 7 of 8 patients (87.5%), compared with 65 of 69 patients (94.2%) with malignant etiologies. Immediate extubation in the bronchoscopy suite was achieved in 49 patients (59.8%), while 24 patients (29.3%) required short-term ventilatory support (<24 hours) following the procedure. Nine patients (11.0%) required prolonged ventilatory support (>24 hours) due to severe airway compromise, procedural complications, or development of hospital-acquired/ventilator-associated pneumonia. The median length of hospital stay was 7 days (interquartile range 5–11). Out of 77/82 (93.9%) patients discharged, 69 patients (89.6%) were discharged without supplemental oxygen, whereas 8 patients (10.3%) required home oxygen therapy. In-hospital mortality occurred in 5 patients (6.1%). One death was attributed to massive endobronchial bleeding, while four deaths occurred due to severe post-procedural infections leading to septic shock and respiratory failure.

Follow-up information was available for 52 patients (75.4%) during the subsequent three months. Three patients (5.8%) died within the first month after discharge, primarily due to severe pneumonia and infectious complications. Two additional deaths occurred during the second month, resulting in a cumulative two-month mortality of 9.6%. One further death occurred during the third month, leading to an overall three-month mortality of 11.5% among patients with available follow-up.

Discussion

This retrospective analysis of 82 patients undergoing rigid bronchoscopic airway interventions highlights the role of RB as an essential tool in the management of complex airway conditions, particularly in tertiary care settings where such cases are frequently encountered.

Our patient cohort shows a mean age of 56.2 ± 12.6 years, with a male predominance (71.9%). The male skew aligns with global gender trends in respiratory interventions, likely reflecting higher smoking rates and occupational exposures among Indian males [9,10]. A recent online national RB survey conducted in India (n=76 operators) revealed that most operators performed RB on adults, and only 43.4% of responders routinely treated pediatric cases also [11].

In the present study, 90.2% of patients (n = 74) had an underlying malignant etiology causing airway obstruction. The most common malignancy was lung cancer, accounting for 68.2% (n = 56) of all cases. This was followed by cancer of the esophagus in 15.8% (n = 13), thyroid in 3.6% (n = 3), and lymphoma in 2.4% (n = 2) of patients. As per our institutional lung cancer registry

data, central lung tumors were encountered in 135 cases over the last 15 months. Squamous cell carcinoma was the most prevalent histological subtype, accounting for 62.2% of these cases. This was followed by adenocarcinoma (24.44%) and small cell lung cancer (10.37%). The predominance of lung cancer as the primary etiology reflects global patterns where thoracic malignancies, particularly non-small cell lung cancer, represent the leading cause of CAO requiring bronchoscopic intervention [12]. This contrasts with a previous study, where 73.7% of RB interventions targeted benign conditions like PITS, foreign body removal, mucous plug and massive hemoptysis [13]. The shift towards malignancy management reflects improved diagnostic capabilities and the rising burden and perhaps late presentation of lung cancer in India, now the most common cancer among males [14]. Our findings align with the existing literature that suggests RB as the procedure of choice in cases of malignant CAO due to its ability to provide diagnostic, therapeutic and palliative benefits [8].

Foreign body removal was the predominant indication for performing RB in earlier Indian studies as per a previous systematic review [13]. In our study, however, the most common indication for performing RB was airway stenting (63.4%) followed by tumor debulking (29.2%). The 2024 national RB survey also reports similar findings, with 73-77% of operators using RB for therapeutic interventions like stent placement [11]. In our cohort, self-expanding metallic stents (SEMS) were utilized in 97% of cases, highlighting a notable contrast with European cohorts, where silicone stents remain more commonly employed. In the EpiGETIF registry, SEMS placement accounted for 44.7% of cases, while in the AQuIRE registry, its usage was comparatively higher at 73.4% [7,8,15,16].

We observed an overall complication rate of 29.3% (n=24) following RB for central airway lesions, with the majority of complications managed conservatively. Only 6% (n=5) of patients required escalated care, and life-threatening complications occurred in 2.4% (n=2) of cases, predominantly due to severe endobronchial bleeding leading to death (n=1) and hypoxia-induced arrhythmia (n=1). A 2014 study and systematic review of therapeutic RB in India noted 47.4% minor complications, with no mortality [13]. Beomsu Shin et al documented a 20.4% complication rate in a retrospective cohort of 98 consecutive patients with malignant CAO due to extra-pulmonary malignancy [17]. The reported complication rates by RB registries are 3.9% in the AQuIRE registry and 10.9% in the multicenter Epigetif study [7,8]. Marta et al. reported a 13.4% overall complication rate, with a subset experiencing severe events including deaths from hemorrhage and respiratory failure [18]. Freitas et al documented the most common complication as haemorrhage (16%) in a prospective cohort including 100 patients, comparable to our cohort

[19]. The differences in complication incidence may be attributable to differences in complication reporting thresholds, as definitions and timing vary considerably across studies. Also, factors including proportion of patients with advanced airway compromise or extensive endobronchial disease, or greater procedural aggressiveness adds to the complication rate.

Life-threatening complications were encountered in 2.4% of our cases, predominantly comprising severe endobronchial hemorrhage and hypoxia-induced arrhythmias. The procedure-related mortality rate in our study was 1.2% (1/82), which is slightly higher than the 0.4% (3/775) reported in a large RB series [18]. Notably, our mortality rate is comparable to that observed in the multicenter EpiGETIF registry, which reported a 1.0% mortality across 2,118 patients from 36 centers [8]. These findings collectively show that even in high-risk populations, RB remains a relatively safe therapeutic modality when performed in experienced centers, with acceptable complication and mortality rates.

Regarding symptomatic improvement and follow-up mortality in our cohort, rigid bronchoscopic recanalization resulted in symptomatic improvement in 87.8% of patients, with improvement seen in 94.2% of malignant cases and 87.5% of benign airway diseases, highlighting the effectiveness of therapeutic bronchoscopy in relieving CAO. These findings are comparable with international registry data. In the EpiGETIF registry, therapeutic bronchoscopy for malignant CAO resulted in symptomatic improvement in approximately 96.3% of patients, demonstrating similar clinical benefit [8]. The 30-day mortality (including in-hospital mortality) of 9.7% (n=8/82) observed in our study is slightly lower than that reported in large registries such as AQuIRE, which reported an overall mortality of 14.8% [7].

In our cohort, follow-up data were available for 52 patients, with a three-month mortality of 11.5%, largely related to infectious complications such as pneumonia and sepsis. Notably, a study by Grosu et al reported that 32% of patients developed lower respiratory tract infections after airway interventions, with 56% requiring hospitalization and 26% dying within 14 days of infection, highlighting the substantial morbidity and mortality associated with post-interventional respiratory infections [20].

The 2014 study from India by Madan et al reflects the traditional role of RB with its primary application being in non-malignant conditions such as PITS and foreign body removal [13]. In contrast, our cohort demonstrated a markedly higher malignancy rate of 90.2%, indicating a significant shift in practice patterns. Several factors likely contribute to this trend - the alarming rise in tobacco consumption in India, with an estimated 267 million users fueling an increasing burden of lung cancer; improved survival among advanced lung cancer patients due to the advent

of novel therapies including immunotherapy [21], which has expanded the potential for palliative airway interventions to maintain airway patency; and the widespread availability and commercialization of stents, facilitating broader adoption of interventional bronchoscopy techniques for malignant airway obstruction.

This study has a few limitations. Its retrospective design and small sample size warrant caution in generalizing the findings. The absence of long-term follow-up data represents a significant gap, underscoring the need for further research. However, the study's real-world insights and detailed analysis are among its key strengths, making it a valuable contribution to the field of interventional bronchoscopy. It emphasizes the growing demand for RB interventions and highlights the critical need for capacity building in this area. For clinicians, the study reinforces the procedure's safety when performed by trained professionals, with a low rate of major complications, while also highlighting the need for long-term follow-up to assess procedural durability. For researchers, it identifies key areas for future investigation, such as comparative studies and larger, multicenter randomized trials to build a stronger evidence base for clinical guidelines.

Conclusions

This study demonstrates a high success rate in managing both malignant and benign airway conditions with RB in a real-world cohort of adult patients. The procedure's ability to provide immediate relief from airway obstruction, coupled with its diagnostic capabilities, makes it an indispensable tool for the interventional bronchoscopist. While complications are not uncommon, they are generally manageable with appropriate expertise and preparation. Dedicated training is essential to enhance experience and ensure optimal outcomes while minimizing procedural risks. Further studies should continue to refine the indications and techniques for RB, with a focus on improving patient outcomes and reducing complication rates. Future efforts should prioritize national/international multicenter registries, simulation-based training expansion and larger studies to further guide RB's integration into the evolving pulmonary care landscape.

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Table 1. Baseline patient characteristics, clinical presentation and etiological diagnosis (n=82).

PARAMETER	VALUE
Demographics	
Mean Age (years) ± SD	56.2 ± 12.6
Male	59 (71.9)
Female	23 (28.0)
Mean BMI (kg/m²) ± SD	20.71 ± 2.24
Presenting Symptoms	
Cough	74 (90.2)
Dyspnea	68 (82.9)
Chest pain	24 (29.2)
Fever	15 (18.2)
Stridor	15 (18.2)
Dysphagia	14 (17.0)
Hemoptysis	11 (13.4)
Etiological Diagnosis	
Malignant (n = 74, 90.2%)	
Lung malignancy	56 (68.2)
Esophageal malignancy	13 (15.8)
Thyroid malignancy	3 (3.6)
Lymphoma	2 (2.4)
Benign (n = 8, 9.8%)	
Post-TB tracheoesophageal fistula/bronchostenosis with hemoptysis/endobronchial growth	3 (3.6)
Post-intubation tracheal stenosis (PITS)	2 (2.4)
ILD under evaluation (for cryobiopsy)	2 (2.4)
Bronchopleural fistula due to corrosive ingestion	1 (1.2)

Table 2. Indications for rigid bronchoscopy (n=82).

INDICATION	NO. OF PATIENTS (%)
Anatomical	
Bronchial growth	21 (25.6)
Tracheal growth	18 (21.9)
Tracheal compression (intrinsic/extrinsic/mixed)	16 (19.5)
Bronchial compression	13 (15.8)
Airway-esophageal fistula	6 (7.3)
Tracheal stenosis (PITS)	3 (3.6)
Therapeutic	
Stenting	52 (63.4)
Tumor debulking	24 (29.2)
Balloon dilatation	13 (15.8)
Stent removal	2 (2.4)
Diagnostic	
High-risk endobronchial biopsy	10 (12.1)
Trans-bronchial lung cryo-biopsy	2 (2.4)

Table 3. Rigid bronchoscopy procedural details, interventional techniques employed and stents used.

PARAMETER	N (%) / VALUE
Rigid barrel size used (Novatech/Karl Storz)	
14	45 (54.9)
12	32 (39.0)
11	5 (6.1)
Procedural Duration	
Vocal cord visualization (seconds), median±IQR	32 ± 14
Tracheal intubation (seconds), median±IQR	38 ± 14
Total procedural duration (minutes), mean±SD	62.8 ± 14.8
Techniques Used	
Stenting	52 (63.4)
Tumor debulking and associated procedures	24 (29.3)
Mechanical debulking	19 (23.1)
Cryo-procedures	14 (17.1)
Balloon dilatation (including PITS)	13 (15.8)
Laser photocoagulation	10 (12.2)
Argon plasma coagulation	5 (6.1)
Diathermy (electrocautery)	5 (6.1)
EBUS-TBNA (staging)	9 (10.9)
Stent removal	2 (2.4)
Stents Used (n=52)	
SEMS (Self-expanding metallic stent)	49 (94.2)
Tracheal stent (straight)	33 (63.2)
Tracheobronchial stent (Y-stent)	11 (22.4)
Bronchial stent	5 (10.2)
Silicone stent	3 (5.7)

Table 4. Complications and anesthesia details.

PARAMETER	FREQUENCY / VALUE
Complications	
Bleeding	24 (29.3)
Bronchospasm	14 (17.1)
Hypoxia	11 (13.4)
Prolonged post-procedure ICU stay (>24 hours)	9 (11)
Hypotension	2 (2.4)
Hypertensive urgency	1 (1.2)
Arrhythmia	1 (1.2)
Major bleeding leading to death	1 (1.2)
Anesthesia Details	
Mean Induction Duration (seconds), mean±SD	62.8±14.8
Mean Reversal Duration (minutes), mean±SD	10.69±2.4
Total Intravenous Anesthesia	76 (92.6)
Combined Inhaled plus Intravenous Anesthesia	6 (7.3)
Muscle Relaxant Used	76 (92.6)