Original Article

Rigid bronchoscopic interventions for central airway obstruction – An observational study

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ABSTRACT

Background: Central airway obstruction (CAO) is a significant cause of morbidity and mortality in patients with thoracic malignancies. In this prospective study, we describe the role of rigid bronchoscopy (RB) in the multimodality management of CAO. **Methods:** Prospective description of different rigid bronchoscopic techniques used for CAO between July 2016 and July 2019. **Results:** A total of 152 procedures (124 therapeutic/palliative and 28 diagnostics) in 111 adults and 10 pediatric patients were performed. The mean age in 111 adults (66 males) and 10 pediatric (5 males) patients were 45.4 ± 15.8 (range 16–80) and 5.4 ± 3.6 (range 1–10) years, respectively. Palliation of the airway obstruction (48.8%) and establishment of diagnosis (23.2%) were the main indications of RB in our study. Mechanical debulking in 53 (57%) and airway dilatation in 40 (43%) patients were the most utilized interventions during the palliative or therapeutic RB. There was a significant decrease in mean (modified Medical Research Council) dyspnea scale from 3.9 ± 1.0 to 1.42 ± 0.63 and increase in mean Visual Analogue Scale from 2.06 ± 0.74 to 8.7 ± 0.54 after the procedure ($P < 0.0001$). Additional therapy was undertaken in 38 (31.4%) of 121 patients, and surgical excision was the primary form of definitive treatment in 17 patients Moderate bleeding was encountered in 13.3% of the procedures mainly in the diagnostic RB. The mean procedure duration was 28.4 (range, 11–49) min and 13.2 (7–22) min in the adults and pediatric patients, respectively. A total of 31 patients succumbed to the illness due to the progressive nature of their disease. **Conclusions:** An individualized approach to interventional procedures is safe and effective way to achieve and maintain palliation of CAO. RB with multimodality treatment achieves the goal in majority of the patients.

KEY WORDS: Central airway obstruction, diagnostic rigid bronchoscopy, interventional pulmonology, lung cancer, therapeutic rigid bronchoscopy, tracheal stenosis

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INTRODUCTION

Central airway obstruction (CAO) involving the trachea and main bronchi is a significant cause of morbidity and mortality among the patients of thoracic diseases presenting with respiratory failure.[1] An estimated 20%–30% of patients with primary lung cancer develop CAO during its course which requires measures to palliate the obstruction.[2] Historically, the approach to potentially unresectable or inoperable malignant central airway lesions had been dependent upon therapeutic rigid bronchoscopy (RB). Despite the versatility and ease of the flexible bronchoscopy, there has been a paradigm

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shift toward RB in recent times for therapeutic and palliative care in such lesions.[3,4] Apart from its many other benefits, the use of RB permits manipulation of multiple instruments within its confines while simultaneously stabilizing the airway and achieving adequate tamponade to limit bleeding. Progress in lung cancer therapies and the advent of modern modalities like argon plasma coagulation, endobronchial laser, and stent placement have further extended the landscape of RB. Immediate relief and a lasting palliative effect provided through these procedures have been the significant contribution of interventional pulmonology (IP). These invaluable benefits of IP warrant its integration into the hands-on teaching and training program of RB.[5]

Combination of various IP modalities is essential, but a flexible approach to CAO management is vital for improvement in the quality of life and symptomatic palliation. It also confers a window of opportunity to facilitate future therapies and change in level of care to reduce patient's suffering.[6-8] A multimodality treatment plan aimed at primarily decreasing the bulk of the lesion is the best way to benefit and salvage a threatened airway when structural and functional deficit widely varies due to malignant or benign diseases. Rapidly securing a stable airway with minimum procedures is the ideal approach to maintain a balance between risk and the benefit. Similarly, the diagnostic utility of RB cannot be undermined in life-threatening vascular central lesions not amenable to flexible scopes. This prospective study aimed at assessment of the technical feasibility, outcomes, and complications of therapeutic and diagnostic RB while using a wide range of interventional options.

METHODS

This prospective observational study was carried out in a tertiary care teaching hospital over a period of 3 years (July 2016–July 2019). The study was approved by the Institutional Ethics Committee, and informed written consent was taken from all patients before the procedure.

Patient selection, preparation and planning
The patients undergoing RB procedures for CAO were included in the study. Patients were excluded if: (a) inability to perform the RB due to anatomical abnormality, (b) significant hemodynamic instability, (c) patients enrolled in other studies during the same period, and (d) failure to give informed consent. All included patients underwent complete physical assessment and routine blood investigation including haemogram, coagulation profile, renal and liver functions, computed tomography of the chest, and arterial blood gas analysis before the procedure. A baseline cardiovascular and respiratory evaluation to assess fitness for the procedure was also performed. Bronchoscopic airway assessment was performed using flexible video bronchoscope (BF-190, Olympus Medical, Japan) to define the location, length, and type of the lesion.

Airway obstruction was quantified and recorded as a percentage of luminal narrowing into Grade 0 to Grade 1–5. If there were no luminal compromise (Grade 0) to decrease in cross-sectional area by 25%, 50%, 75%, 90%, or 100%, respectively, as described by Freitag *et al.*[9] A Combination of direct visualization with the flexible bronchoscope and radiological imaging formed the basis for the preprocedural planning and selection of the safest and most appropriate airway intervention.

Anesthesia
Combined airway blocks with intravenous anesthetics were used. An airway block was given using 2 ml of intratracheal 4% lignocaine through the cricothyroid membrane and 1 ml of 2% lignocaine for superior laryngeal nerve block on each side. Patients were preoxygenated with 100% O_2 before the sedation with titrated doses of midazolam (1–2 mg), fentanyl (2–3 mcg/kg), and propofol (100–200 mcg/kg). While preserving the spontaneous respiration, propofol infusion (50–100 mcg/kg/h) was used for safer tolerability during airway instrumentation. Neuromuscular blocker was given only when required after adequate airway patency was established. Neostigmine (0.05 mg/kg) and glycopyrrolate were used at the end of the procedure for anesthesia reversal, and patients were extubated once the patient regained adequate consciousness and spontaneous respiratory control.

Rigid bronchoscopy
Rigid bronchoscopies were performed using 3.5–14 mm scopes with a proximal illumination and a telescope (Karl Storz GmbH and Co., KG, Germany). With the patient in supine position, the head was partially extended at the atlanto-occipital joint to align the oral, pharyngeal and laryngeal axes in one plane for a linear route through the vocal cords. Both direct and indirect rigid intubation were utilized as per the previously described procedure.[3]

Therapeutic/palliative procedures
Dilation was primarily utilized for an extraluminal or mixed variety of airway obstructions. Serial dilatations with successively larger scopes or a single step dedicated optical dilation tracheoscope were used for rigid dilatation. Graded balloon dilation was performed using a controlled radial expansion pulmonary balloon (CRE™, Boston Scientific, USA) threaded over a guidewire with burst pressure ranging from 6 to 10 atmospheres.

Mechanical coring/debridement
A core out technique was used for debulking the intraluminal and mixed type of lesions. Compression due to the scope barrel while coring allowed tamponade of bleeding.

Electrocautery, neodymium-doped:yttrium-aluminum-garnet (Nd:YAG) laser, argon plasma coagulation, and cryoablation were used as adjuncts to mechanical coring for partially debrided lesion, distal or inaccessible lesions, and obstructive granulation tissue.

However, the use of ablative therapies was restricted to intraluminal exophytic lesions to avoid airway perforation or fistula formation.

Tracheobronchial stenting

Stents were placed for critical airway narrowing due to in extra luminal lesions or persistent obstruction following other interventions. Self-expanding metallic or silicone stents were selected based on malignant or benign disease. Stents were placed according to the method previously described.[3,10]

Diagnostic procedures

For vascular airway lesions located centrally with a high risk of bleeding, a RB guided biopsy under general anesthesia was performed. Maximum of 3–5 samples were obtained from the most diseased location, and hemostasis was achieved in all diagnostic procedures.

Flexible video bronchoscope passed through the lumen of the RB was often used during the procedure to explore and visualize the distal airways and to ensure the adequacy of the process. Intervention is performed using rigid instruments, and flexible scope through the RB was also used for additional modalities such as laser, argon plasma coagulation, and cryotherapy. Single intubation with RB was defined as a procedure, and during the procedure, use of unique or multimodality technique such as mechanical debridement, balloon dilatation, electroablation, or cryotherapy were defined as interventions.

Descriptive data of the study are presented using mean (standard deviation), median (interquartile range), or number (percentages).

Outcome

The outcome was defined as successful if adequate luminal patency of more than 50% was achieved after the multimodality interventions. Bleeding during the procedure was categorized as (1) mild, if it was easily controlled by suction and/or adrenaline instillation, (2) moderate, if significant effort was required to control the bleeding, and (3) severe, if further procedure could not be completed due to hypoxemia (SpO_2 <85%) while on assisted ventilation through the rigid bronchoscope.

RESULTS

A total of 121 patients underwent RB procedure at our tertiary care center, including 111 adults and 10 pediatric patients. The mean age in adult (66 males) and pediatric (5 males) patients were 45.4 ± 15.8 (range 16–80) and 5.4 ± 3.6 (range 1–10) years, respectively. The baseline characteristics of the patients are given in Table 1. All patients were symptomatic at presentation with dyspnea (98.4%) and cough (88.5%). About one-third of the patients presented with stridor (31.4%) while respiratory failure was seen in 48 (39.7%) patients. The mean modified

Table 1: Baseline characteristics of patients (*n*=121)

Characteristics	*n* (%)
Demographics	
Adult (*n*=111)	
Age	45.4±15.8
Male:female	66:45
Pediatrics (*n*=10)	
Age	5.4±3.6
Male:female	5:5
Symptoms	
Dyspnea	119 (98.4)
Cough	107 (88.5)
Wheezing	57 (47.1)
Hemoptysis	43 (35)
Stridor	38 (31.4)
Chest pain	9 (7.6)
Respiratory failure	23 (19)
Chest radiology	
Mass	49 (40.5)
Collapse (obstructive pneumonia)	29 (24)
External compression of the airway	13 (10.8)
Foreign body	12 (9.9)
Benign tracheal stenosis	16 (13.2)
Others	2 (1.7)
Bronchoscopic findings	
Mass	54 (44.7)
Infiltration	30 (24.8)
Extrinsic compression	13 (10.8)
Foreign body	12 (9.9)
Airway stenosis	12 (9.9)
Airway obstruction grading	
Grade 0	0
Grade 1	0
Grade 2	11 (9.1)
Grade 3	31 (25.6)
Grade 4	25 (20.7)
Grade 5	52 (43)

Medical Research Council (mMRC) scale for dyspnea and visual analog scale (VAS) score at baseline were 3.9 ± 1.02 and 2.06 ± 0.74, respectively.

During the bronchoscopic assessment, endobronchial mass (44.7%) and infiltrative lesion (24.8%) causing airway obstruction were the main observations. A luminal obstruction was categorized as Grade 3–5 in 108 (89.3%) individuals. A total of 152 procedures were performed in 121 patients with an average of 1.26 procedures per patient. Palliation of the airway obstruction (48.8%) and establishment of diagnosis (23.2%) followed by therapeutic interventions were the main indications of RB in our study. Mechanical debulking in 53 (57%) and airway dilatation in 40 (43%) patients were the most utilized interventions during the palliative or therapeutic RB. Local ablative therapies such as electrocautery, argon plasma coagulation, or Nd: YAG laser were effectively used for procedure-related bleeding and debulking of remaining lesions. The mean procedure duration was 28.4 (range, 11–49) min and 13.2 (range 7–22) min in the adults and pediatric patients respectively. Diagnostic RB was used in 28 patients with vascular lesion within the central airway having a high risk of bleeding. In these 28 patients balloon occlusion of the biopsied segmental or lobar bronchi was

required in 11 patients, and electrocautery facilitated hemostasis in 3 patients. In 12 patients endobronchial stents were placed to stabilize the airway and in 7 patients these stents were removed following definitive therapy. In majority of the patients silicone stents were used. Details of airway interventions performed are given in Table 2.

Most of the patients recovered from general anesthesia immediately after the procedure and only 8 of the 152 procedures required endotracheal intubation and ventilation. However, all such cases were extubated within 24 h. The mean (mMRC) scale for dyspnea fell from 3.9 ± 1.0-1.42 ± 0.63 while the mean VAS increased from 2.06 ± 0.74 to 8.7 ± 0.54 after the procedure ($P < 0.0001$). Due to significant immediate relief in airway obstruction as well as the clinical parameters, majority of the patients were discharged within 48–72 h. Additional therapy was undertaken in 38 (31.4%) of 121 patients, and surgical excision was the primary form of definitive treatment in 17 patients. Complex tracheal stenosis, neuroendocrine tumor, and thyroid malignancy were the main indications for surgical treatment. Combination of chemotherapy or radiotherapy was used in remaining patients. Histopathological diagnosis is given in Table 3.

Minor bleeding, hypotension, and hypoxemia complicated the procedure transiently during RB. Pneumomediastinum and airway laceration after mechanical debulking were seen in 2 patients, which improved with conservative management [Table 4]. Moderate bleeding was encountered in 13.3% of the procedures mainly in the diagnostic RB. During the follow-up, reintervention was required in 31 patients for stent removal, re-debulking, and additional stent placement. Respiratory tract infection requiring antibiotic therapy was seen in 7 (5.8%) patients. The mean duration of follow up was 8.6 months with the longest follow-up of 17 months in patients with stents. A total of 31 patients succumbed to the illness due to the progressive nature of their disease. No deaths occurred in immediate periprocedure period; however; one patient in a diagnostic RB group (diagnosed as angioinvasive mucormycosis) died of massive hemoptysis during the hospital course.

DISCUSSION

The results of this study highlight the extensive use of therapeutic and diagnostic RB in a heterogeneous population with widely variable complex CAO. Its main advantage is the good safety profile and ability for sustained ventilation and superior control of airway while salvaging a threatened airway with multimodality approach.[6-8] In contrast to the previous reports focusing on a single modality treatment, the procedural algorithm in this series uniquely approached each patient with a predetermined set of therapeutic and diagnostic interventions. The choice of the procedure in this study was customized based on the nature of the disease (malignant or benign), type of obstruction (extrinsic, intrinsic or mixed) and acuity of the condition.[11-13] One of the main findings of airway obstruction by primary lung cancer (squamous cell carcinoma and adenocarcinoma) in this series is comparable to the previous reports.[4] Primary tracheal tumors (adenoid cystic carcinoma or bronchial carcinoid) were seen in only 21 (17.4%) of the 121 patients.[14,15] Despite surgery and radiotherapy being the treatments of choice in such patients, most in our study underwent palliative RB due to inoperability, distant metastases, respiratory compromise, and delayed or unpredictable response to chemoradiotherapy. Similar to previously published experience of rigid bronchoscopic interventions in locally advanced malignancies, RB provided improvement in the overall respiratory status of all patients, which was the primary aim of interventions in our study.[6,7,16] The finding of mechanical debulking as the main indication for RB in our study is in contrast to the earlier report of

Table 2: Airway interventions during rigid bronchoscopy (*n*=121)

Airway procedures	*n* (%)
Therapeutic/palliative interventions (*n*=93)	
Mechanical coring	53 (57)
Endobronchial stenting	12 (12.9)
Mechanical dilatation	17 (18.2)
Balloon dilatation	23 (24.7)
Argon plasma coagulation	16 (17.2)
Cryoablation	19 (20.4)
Endobronchial laser	9 (9.7)
Stent removal	7 (7.5)
Foreign body removal	12 (12.9)
Procedure duration adults, mean±SD (min)	28.4±7.5
Procedure duration pediatrics, mean±SD (min)	13.2±4.6
Diagnostic procedures (*n*=28)	
Endobronchial biopsy	28 (100)

SD: Standard deviation

Table 3: Histopathological location of the lesion and type of procedure (*n*=94)

Histology	Trachea	Carina	Bronchus	Therapeutic	Palliative	Diagnostic
Squamous cell carcinoma	13	7	10	0	24	6
Adenocarcinoma	5	4	4	0	10	3
Adenoid cystic carcinoma	7	0	2	0	6	3
Neuroendocrine tumor	1	3	8	2	3	7
Lymphoma	6	0	2	0	8	0
Thyroid carcinoma	2	0	0	0	2	0
Metastatic carcinoma	2	0	9	0	6	5
Lipoma	2	0	4	3	0	3
Airway granulation (postintubation)	5	0	0	5	0	0
Mucormycosis	0	0	1	0	0	1

Table 4: Complications during rigid bronchoscopic interventions (*n*=121)

Complications	*n* (%)
Moderate bleeding	16 (13.3)
Hypoxia	2 (1.6)
Arrhythmia	3 (2.4)
Hypotension	2 (1.6)
Pneumomediastinum	2 (1.6)
Pneumothorax	1 (0.8)
Vocal cord injury	1 (0.8)
Respiratory infection/pneumonia	7 (5.8)

benign tracheal stenosis as the main indication of RB which could be due to small number of patients included in the earlier study and possible referral bias for malignant airway lesions to our center.[17]

With advances in the techniques of IP, isolated use of mechanical debulking is debated, however, RB alone or in conjugation with electro-ablative and laser therapy is an effective, quick, and safe method for debulking airway obstruction as evident by the most common intervention in our study.[18-21] Maintaining the barrel of the scope parallel to the airway along its axis for mechanical coring and bleeding tamponade is a rapid and convincing method of relieving CAO.[20] In few selected patients, mechanical debulking also facilitated better delineation of the tumor margins and lung functions before the definitive surgery. This approach is consistent with the reported benefit of interventional bronchoscopic procedures improving preoperative lung functions, and permitting parenchyma sparing surgery in patients with lung cancer.[22] Electroablation, laser, and cryotherapy can be conveniently performed through the flexible scope; however, in this study, flexible scope was used to deliver these techniques through the RB which stabilized the airway.[19,21,23] Use of ablative therapy as part of the multimodality treatment has the potential to reduce the bleeding and was successfully used in our study to avoid complications.[7]

Presence of nonspecific symptoms in early disease quite often delays the diagnosis of benign CAO until patients present with acute symptoms.[2,24] Stridor and respiratory failure was the commonest mode of presentation in our patients with benign tracheal stenosis caused by iatrogenic endotracheal intubation or tracheostomy. Rigid bronchoscopic and balloon dilations were performed as first options to establish adequate airway patency in 5 patients before definitive resection and anastomosis.[25-27] Local application of mitomycin C through RB during dilatation procedure has been evaluated in small series with equivocal results, however, this modality was not contemplated in any of our patients.[28] Successful combination of mucosal-sparing Nd: YAG laser photo-resection, dilatation with balloon or dedicated optical tracheal dilator, and stenting in remaining 11/16 (68.8%) patients were similar to previously reported outcome.[29] These interventions optimize the patient's condition and do not hamper the future surgical outcome. The final success rate of tracheal

stenosis which varies between 40% and 80% was 75% in our patients after combined modality treatment.[30,31]

Due to the secondary involvement, the overall prognosis of the tracheobronchial tumor is poor and was seen in 31 patients in this study who succumbed to their illness despite adequate palliation.[32] In selected malignant CAO, use of multimodality bronchoscopic interventions significantly improves the survival by serving as a bridge to additional therapies.[7,16] Similar to these findings, the addition of surgery, chemotherapy, and radiotherapy after the palliative or diagnostic RB procedure favorably changed the overall prognosis of patients in our study.[22]

Although due to the availability of newer modalities, the diagnostic yield of flexible bronchoscopy has increased, it may still have limited role in patients with vascular lesions with high risk of bleeding, compromised airways, and respiratory failure. While maintaining an equivalent use of therapeutic RB, noteworthy in our study is the use of diagnostic RB in 28 patients.[33] Electrocautery enable forceps through flexible scope can be used to avoid bleeding during the endobronchial biopsy but at times it can be risky in central lesions due to potential compromise of the airway during the procedure.[34] Instead, in such situations, RB offers a safer means to obtain a tissue with an advantage of using additional interventions to control the bleeding.

The major limitation of our study is the absence of a control group; however, randomization is difficult in such patients when majority of the procedure was done for palliation of symptoms. Inability to use spirometry for the measurement of lung function at the baseline due to life-threatening airway compromise and sole use of clinical assessment for assessing the overall improvement and outcome, instead of validated scoring system is another limitation of this study. Despite all odds, RB still stands invaluable as an excellent tool that mainly remain underutilized due to lack of required training and infrastructure. However, there is a need to expand the expertise of RB to deliver balanced therapeutics in compromised airway and extending its role as a diagnostic tool. In our experience, if the precise indication is followed, the complications associated with RB can be minimized in the hands of a trained person.

CONCLUSIONS

RB will not only expand in its role but also is likely to assume greater importance as advances in supplementary procedures continue to grow in the modern era. It is not only the performance of RB as a procedure; IP has in fact evolved into a subspecialty providing safe and effective palliative and diagnostic care.

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Conflicts of interest

There are no conflicts of interest.

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