Original Article

Therapeutic bronchoscopic interventions for nonmalignant central airway obstruction provide rapid and sustained improvement in symptoms and functional status

Prajowl Shrestha¹, Karan Madan¹, Vijay Hadda¹, Ashish Upadhyay², Saurabh Mittal¹, Pawan Tiwari¹, R. M. Pandey², Rakesh Garg¹, G. C. Khilnani¹, Randeep Guleria¹, Anant Mohan¹

¹Department of Pulmonary, Critical Care and Sleep Medicine, All India Institute of Medical Sciences, New Delhi, India, ²Department of Biostatistics, All India Institute of Medical Sciences, New Delhi, India, ³Department of Oncoanesthesia and Palliative Medicine, All India Institute of Medical Sciences, New Delhi, India

ABSTRACT

Background: Central airway obstruction (CAO) is a potentially lethal condition that requires urgent endobronchial intervention and may occur due to several nonmalignant causes. The effect of these interventions on clinically relevant outcomes such as symptomatic and functional status over a period of time is, however, sparsely studied. Materials and Methods: Consecutive patients with CAO due to nonmalignant causes and undergoing various therapeutic bronchoscopy procedures were evaluated. Symptoms were assessed using the Visual Analog Scale (VAS) and Speiser score, and functional status was assessed using the 6-min walk test, spirometry, and St. George Respiratory Questionnaire (SGRQ) score at baseline and after 48 h, 4 weeks, and 12 weeks postprocedure. Results: Over 2 years, 31 patients with CAO due to nonmalignant etiology underwent 41 therapeutic bronchoscopic procedures. Majority of procedures (96.8%) were done using the rigid bronchoscope under general anesthesia. Postintubation tracheal stenosis was the most common indication (32.2%). The various procedures included, controlled radial expansion balloon dilatation of the stenotic airway (53.6%), deployment of silicone stents (19.5%), and mechanical debulking of airway tumors (16.1%). Significant improvement occurred in dyspnea and cough scores and in the Speiser score from baseline to 48 h postprocedure, and further improved at 4 weeks and 12 weeks. Similarly, the 6 min walk distance, forced expiratory volume in 1 s, and SGRQ scores progressively improved from baseline to 12 weeks. Complications occurred in 26.8% of total procedures, with no procedure‑related mortality. Conclusion: Therapeutic bronchoscopy interventions provide rapid and sustained benefits in symptoms and functional status of participants with CAO of nonmalignant etiology, with an acceptable safety profile.

KEY WORDS: Central airway obstruction, quality of life, therapeutic bronchoscopy

Address for correspondence: Dr. Anant Mohan, Department of Pulmonary, Critical Care and Sleep Medicine, All India Institute of Medical Sciences, New Delhi, India. E-mail: anantmohan@yahoo.com

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INTRODUCTION

Central airway obstruction (CAO) is defined as the obstruction of major airways, namely the trachea and...
the main bronchi and may occur as a consequence of benign or malignant disease. CAO due to benign etiology includes causes such as tracheal stenosis after prolonged endotracheal intubation, tracheostomy, airway trauma, benign airway tumors, tracheobronchomalacia, and granulation tissue in participants undergoing lung transplantation.\[1\] The quality of life of most patients with significant CAO is seriously impaired by dyspnea, stridor, or respiratory failure.\[2\] While surgical resection is the treatment of choice, many patients are inoperable, too unwell, or have significant comorbidities that exclude them from this modality. Interventional therapeutic bronchoscopy procedures such as airway stent insertion, laser, electrocautery, cryotherapy, and argon-plasma coagulation are alternative modalities that may provide immediate benefits.\[3,4\] We recently reported that various therapeutic bronchoscopy interventions provide rapid and sustained improvement in symptoms and functional capacity in CAO of malignant etiology.\[5\] However, a similar assessment of patients with CAO of nonmalignant cause has been sparsely reported. In addition, most studies have evaluated survival but not the short-term or long-term impact on other clinically relevant outcomes. As this knowledge is essential for a true reflection of the clinical utility of any procedure, we conducted this prospective observational study to evaluate the clinically relevant outcome parameters over a 12-week period following various endobronchial interventions in patients with CAO due to benign etiology.

**SUBJECTS AND METHODS**

This was a single-center, prospective, observational cohort study over a 2-year period conducted in the department of Pulmonary, Critical care, and Sleep medicine at a large tertiary-level university hospital in North India. Consecutive patients with CAO due to nonmalignant causes and undergoing therapeutic interventional bronchoscopy were included in the study.

The primary objective was to assess the symptomatic and functional improvement after endobronchial procedures over a 12-week period in patients with CAO due to nonmalignant causes. In addition, the short-term survival after 3 months and the complications associated with the various procedures were also recorded. Prior ethical approval was obtained from the Institutional Ethics Committee.

After obtaining written informed consent, all patients were managed on an Excel spreadsheet. Continuous variables were expressed either as mean ± standard deviation (SD) or median (min-max). Pre- and post-procedure comparisons were done for various parameters; the Chi-square test was used to compare the variables expressed in mean ± SD; and Friedman test was used for the variables expressed in median (min-max). Statistical analysis was performed using StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP.

**RESULTS AND OUTCOMES**

Over the period of 2 years, 31 patients with CAO due to nonmalignant etiology underwent various therapeutic bronchoscopic interventions. These included 17 females (55%), with an overall mean (SD) age of 32.3 (13.8) years (range, 15–56 years). The majority of procedures (96.8%) were done using the rigid bronchoscope (Karl Storz, Germany) under general anesthesia.

The baseline symptomatic and functional assessments are shown in Table 1.

Among all patients, postintubation tracheal stenosis (PITS) was the most common etiology of CAO (32.2%), followed by posttubercular tracheobronchial stenosis (22.5%), carcinoid tumor of airway, inflammatory myofibroblastic tumor, granulomatosis with polyangiitis, allergic bronchopulmonary aspergillosis, and fibrosing mediastinitis [Figure 1]. The midtrachea was the most common location of obstruction (25.8%), followed by the lower trachea (22.5%) and upper trachea (19.3%). The right main and left main bronchi were affected in 12.9% and 19.3% of patients, respectively [Figure 2].

A total of 41 different interventions were done in these 31 patients and are depicted in Table 2. Controlled radial expansion (CRE) balloon dilatation of the stenotic airway was the most common intervention performed (53.6%), followed by deployment of silicone stents in 8 (19.5%) and mechanical debulking of airway tumors (16.1%). Several patients underwent a combination of multiple procedures, most commonly balloon dilatation followed by stenting.

Comparison of symptomatic and functional assessment at baseline and at 48 h, 4 weeks, and 12 weeks following the procedure. A comparison was made between the baseline parameters with the same measured at 48 h, 4 weeks, and 12 weeks postprocedure. Procedure-related complications were recorded as “early” (occurring within 48 h of interventions) or “late” (those occurring after 48 h).

**Statistical analysis**

Data were entered in an access database and were exported to be managed on an Excel spreadsheet. Continuous variables were expressed either as mean ± standard deviation (SD) or median (min-max). Pre- and post-procedure comparisons were done for various parameters; the Chi-square test was used to compare the variables expressed in mean ± SD; and Friedman test was used for the variables expressed in median (min-max). Statistical analysis was performed using StataCorp.
Table 1: Baseline symptomatic and functional assessment of patients with central airway obstruction

| Parameter                        | Value               |
|----------------------------------|---------------------|
| Dyspnea VAS score                | 7.5 (0.5-9.0)       |
| Cough VAS score                  | 6.0 (0.5-8.8)       |
| Speiser score                    | 6.0 (1-11)          |
| 6 MWD (m)                       | 318±59.2            |
| FEV1 (L)                         | 1.34±0.60           |
| FVC (L)                          | 2.19±0.87           |
| St. George Quality of Life Score |                     |
| SGRQ - S (symptoms)             | 75.9±16.0           |
| SGRQ - A (activity)             | 64.1±17.7           |
| SGRQ - I (impact)               | 58.6±17.5           |
| SGRQ - T (total)                | 66.6±16.8           |

Values expressed as median (minimum-maximum) or mean±SD. VAS: Visual Analog Scale; 6MWD: 6 min walk distance; FEV1: Forced expiratory volume in 1 s; FVC: Forced vital capacity; SGRQ: St. George Respiratory Questionnaire; SD: Standard deviation

Table 2: Various endobronchial interventions performed in the study group (n=31)

| Procedure performed                             | n (%) |
|--------------------------------------------------|-------|
| Balloon dilatation/bronchoplasty                  | 22 (53.6) |
| Silicone stenting                                 | 8 (19.5)  |
| Mechanical debulking                               | 5 (16.1)  |
| Electrocautery dilatation/incision                 | 4 (12.8)  |
| Mucus plug removal                                 | 2 (6.4)   |
| Total                                             | 41     |

Table 3: Comparison of symptomatic assessment done at baseline, at 48 h, 4 weeks, and 12 weeks postprocedure in central airway obstruction (n=31)

| Parameters (VAS) | Baseline | At 48 h | At 4 weeks | At 12 weeks | P**       |
|------------------|----------|---------|------------|-------------|-----------|
| Dyspnea VAS      | 7.5 (0.5-9.0) | 2.2 (0-5) | 1.0 (0-9.5) | 0.5 (0-7) | <0.001    |
| Cough VAS        | 6.0 (0.5-8.8) | 2.0 (0-6) | 1.0 (0-8.6) | 0.5 (0-6.5) | <0.001    |
| Speiser score    | 6.0 (1-11) | 2.0 (0-6) | 1.0 (0-10) | 1.0 (0-11) | <0.001    |
| 6MWD (m)         | 318       | 385.6   | 416.5      | 449         | <0.001    |
| FEV1 (L)         | 1.34      | 1.70    | 1.84       | 1.93        | <0.001    |
| FVC (L)          | 2.19      | 2.35    | 2.49       | 2.64        | <0.001    |
| SGRQ - S         | 75.9      | 45.9    | 35.6       | 28.7        | <0.001    |
| SGRQ - A         | 64.1      | 36.4    | 27.5       | 20.0        | <0.001    |
| SGRQ - I         | 58.6      | 32.2    | 24.1       | 17.1        | <0.001    |
| SGRQ - T         | 66.6      | 37.5    | 28.5       | 20.9        | <0.001    |

*Chi-square test; All values expressed in mean±SD; *Friedman test. Values are given in median, minimum, and maximum; *Values available for 20 participants; **All parameters statistically significant when compared between baseline and 48 h, 4 weeks and 12 weeks. VAS: Visual Analog Scale; 6MWD: 6 min walk distance; FEV1: Forced expiratory volume in 1 s; FVC: Forced vital capacity; SGRQ: St. George Respiratory Questionnaire; SD: Standard deviation

DISCUSSION

In this prospective observational study, we observed that appropriate bronchoscopic interventions provided significant improvement in symptomatic and functional status of patients with CAO due to nonmalignant etiology. Complications occurred in 26.8% of procedures, with majority of them being of minor severity. No procedure-related mortality occurred during the 3-month follow-up period.

The most common etiology of CAO in our study was PITS (32.2%) followed by posttubercular tracheobronchial stenosis (22.5%) and bronchial carcinoid (9.6%).
middle and lower trachea were the most common site of stenosis, 25.8% and 22.5%, respectively. Compared to CAO due to malignant diseases, nonmalignant CAO has been less extensively studied, although these conditions comprise a significant proportion of patients. Various prospective and retrospective studies have reported that 33%-53% of all patients with CAO are of nonmalignant etiology.[2,4-8] PITS remains the most common reported cause of nonmalignant CAO in most studies, including ours.[2,4,9,10] Compared to most Western literature, we found a high occurrence of posttubercular stenosis among our patients (22.5%), a finding similar to that reported in some previous studies, notably with Asian subjects.[11,12] Although mortality is low, the impairment of QOL and degree of functional compromise make benign CAO an important health issue. The impact of treatment should, therefore, be weighted according to the benefits obtained in these morbidity parameters. Patients usually present with exertional dyspnea that may be nonspecific and mild to begin with but may progress to severe wheezing and stridor in critical airway stenosis.

The primary aim of managing CAO is to relieve symptoms and improve the quality of life. Several bronchoscopic procedures are employed for treating nonmalignant CAO. These include balloon dilatation,[13] mechanical debulking, heat therapies such as electrocautery incisions or snaring,[14,15] stenting,[16,17] or a combination of these modalities.[18] The choice of procedure depends on the underlying disease, degree of anatomical compromise, and available facilities and expertise. Bronchoscopic airway dilatation followed by stenting is usually the preferred methods for managing CAO due to localized stenosis,[18,9,13] whereas mechanical debulking is usually employed for obstruction due to granulation tissue. Among our patients, CRE balloon dilatation was the most common procedure performed (53.6%) followed by silicone stenting of the trachea (19.5%) and mechanical dilatation of airways (16.1%). This is a different approach from CAO of the malignant cause, wherein stenting was recently reported as the most common intervention performed for palliation.[15] This might suggest that interventionalists tend to avoid endobronchial stenting in CAO of nonmalignant etiology, probably due to the long-term complications associated with this procedure. In a few patients, a combination of procedures were employed, most commonly balloon dilatation followed by stenting (n = 4). In such scenarios, balloon dilatation achieves a success rate up to 98.6% in short term and 73.3% in the long term and is more successful in simple stenotic lesions than that of complex stenosis.[13]

Till date, very few studies have attempted to perform a focused assessment of symptomatic and functional benefit after various airway interventions for CAO of nonmalignant etiology. Most reports focus only on symptoms or pulmonary functions instead of functional capacity. Kim et al.[12] demonstrated improvement in FEV1 and forced vital capacity (FVC) 1 month after procedure in all of their 24 patients with CAO. Similarly, Chung et al.[11] performed 116 SEMS deployment procedures in 72 patients with CAO of nonmalignant etiology and reported immediate symptomatic relief in dyspnea in 76.7% participants.

We observed significant improvement in cough, dyspnea, and Speiser’s symptomatic score immediately after the bronchoscopic intervention; the benefit continued up to 12 weeks [Figure 3]. Similarly, the functional status (i.e. 6 MWD) and quality of life improved progressively till 12 weeks [Figure 4]. An India study has previously shown improvement in symptoms and QOL after rigid bronchoscopic procedures done primarily for benign lesions.[18] Another small study of post-lung transplant recipients with airway stenosis who underwent therapeutic bronchoscopy demonstrated improvement in dyspnea, FVC, FEV1, and quality of life after 6–8 weeks of procedure.[19] The unique feature of the current study is the comprehensive and sequential evaluation of symptoms as well as functionality after various procedures for nonmalignant CAO.

We encountered procedure-related complications in 26.8% of all procedures, with majority being late complications (17.1%), particularly stent-associated granulation tissue (50% of all silicon stents) and stent migration in two cases (25%) that required repositioning. The complication rate following the bronchoscopic management of CAO has been variable, ranging from 0.9% to 11.7%.[20] These are, however, mostly based on the procedures done for malignant CAO and corresponding results for CAO due to nonmalignant causes are sparse. Cosano Povedano et al.[12] reported early and late complications in 3.4% and 34% out of 320 therapeutic bronchoscopy procedures, respectively, whereas Madan et al.[16] reported a complication rate of 36% in 50 procedures. These, however, are likely to depend heavily on the patient profile and expertise available at each center.

Our study has limitations. The study group is relatively small; however, most previous studies on CAO due to benign causes have also been small probably due to the lack of adequate patients in this group compared to malignant CAO. Second, we did not quantify the degree...
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CONCLUSION

CAO due to nonmalignant causes can be effectively and safely managed using various therapeutic bronchoscopy procedures that provide immediate and sustained symptomatic relief and improvement in functional status.

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Conflicts of interest
There are no conflicts of interest.

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