Literature Review

Therapeutic Bronchoscopy in Benign Central Airway Obstruction

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Abstract

Benign central airway obstruction (BCAO) may occur in patients with post-intubation, tracheostomy, tuberculosis and non-tuberculosis infections, tracheal wall abnormalities, endobronchial benign tumors, vascular abnormalities, benign thyroid tumors and external mechanical compression. The management of BCAO is based on the underlying disease and requires multidisciplinary joint decisions from interventional pulmonology, thoracic surgery, radiology and anesthesia. Therapeutic bronchoscopy for the management of BCAO emergencies includes balloon dilation, stents and lasers.

Keywords: Therapeutic bronchoscopy, BCA (BCAO), balloon dilation, stents, laser

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INTRODUCTION

Benign central airway obstruction (BCAO) may occur in patients after intubation, tracheostomy, tuberculosis infection, surgery, sarcoidosis, polychondritis, and benign endobronchial tumors tracheobronchomalacia (TBM), external mechanical compression, transplantation and idiopathic.[1–3] BCAO requires multidisciplinary collaboration, including radiologists, thoracic surgery, interventional pulmonologists, and anesthesiologists.[2]

Bronchoscopy and its devices can serve as therapeutic tools, external radiation, and chemotherapy.[1] Examination of major airway disorders, including oropharynx, larynx, vocal cords, and tracheobronchitis system, and their management can use a rigid bronchoscope with a flexible bronchoscope.[2,4] This narrative review explores the variants of BCAO and therapeutic bronchoscopy in management of BCAO.

DEFINITION AND CLASSIFICATION OF CENTRAL AIR TRACT OBSTRUCTION

Central airway obstruction is occlusion of >50% of the trachea, main bronchi, intermedius bronchi, and lobar bronchi.[3] Histological anatomy of the trachea consists of 4 layers, namely the deep mucosal layer, submucosal layer, muscle and cartilage, and adventitia layer, including lymph nodes and connective tissue (Figure 1).

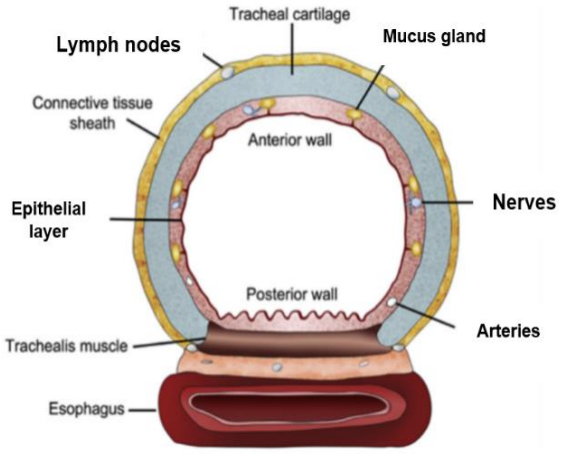

Figure 1. Trachea anatomy, horseshoe-shaped cartilaginous ring on the anterior-lateral tracheal wall.[3]

The anterior trachea is composed of 16–22 C-shaped cartilaginous rings. The function of tracheal ring is to maintain airway patency during expiration so that it does not collapse. The posterior tracheal wall is devoid of cartilage, only composed of smooth muscles and tracheal muscles. The length of trachea is about 10-12 cm in adults, measured from the cricoid to the carina (craniocaudal). The coronal diameter of trachea in male is about 13–25 mm and in women is about 10–21 mm; the thickness of tracheal wall is about 1–3 mm.[2]

Table 1. Classification of tracheal obstruction based on the severity of narrowing of the tracheal cross-sectional area.[3]

Level of obstruction	Description of narrowing of the tracheal cross-sectional area
1	Normal: no narrowing of the tracheal cross-sectional area
2	Mild: narrowing of the tracheal cross-sectional area <50%
3	Moderate: narrowing of the tracheal cross-sectional area 51 – 70%
4	Severe: narrowing of the tracheal cross-sectional area > 71%

The mild narrowing reduces the cross-sectional area of trachea by 50%, and the pressure drop is the same as the glottis closure so that it does not cause symptoms. Moderate obstruction reduces the cross-sectional area of trachea by 51–70%, causing various symptoms. There is a significant decrease in pressure at high airflow, for example, during exercise. However, patients who perform mild activities are usually asymptomatic with moderate obstruction. Severe obstruction, i.e., reduction of tracheal cross-sectional area >71%, causing a significant decrease in pressure even with low airflow, causing symptoms at rest and mild activity, requiring immediate treatment, classification of obstruction based on the severity of narrowing of the tracheal cross-sectional area is outlined in Table 1.[3]

Signs and symptoms of BCAO conform the etiology, location, and severity of the underlying disease. Signs and symptoms which often perceived by patients include shortness of breath during activity, shortness of breath, stridor, and chronic wheezing. Clinicians often make a differential diagnosis of asthma and chronic obstructive pulmonary disease (COPD). Stridor often occurs when the diameter of the tracheal stenosis is <5 mm, occurs during rapid and deep inspiration by opening the mouth.[5]

BCAO MECHANISM

Benign central airway obstruction is obstruction of the central airways that, including the trachea and main bronchi, is caused by other than malignancy. The mechanism of airway obstruction is due to intraluminal lesions, extrinsic compression, and weakness of the tracheal cartilage leading to dynamic tracheobronchial collapse. The diagnosis of benign central airway obstruction is often delayed because of atypical symptoms. Several diseases may lead to BCAO, as summarized in Table 2.[5,6]

Table 2. Diseases that cause BCAO[5–7]

Abnormalities/lesions	Underlying disease
Post-traumatic	Post-tracheal intubation injuries
	Post tracheostomy injury
	Tracheobronchial stenosis associated with stent placement
	Granulation tissue due to foreign body aspiration
	Respiratory tract trauma
	Radiation
	Toxic gas inhalation
Inflammatory disease of the respiratory tract	Granulomatosis polyangiitis
	Amyloidosis
	Sarcoidosis
	Idiopathic laryngotracheal stenosis
Endobronchial benign tumour	Squamous cell papilloma
	Papillomatosis
	Hamartoma
	Leiomyoma

Abnormalities/lesions	Underlying disease
Endobronchial benign tumour	*Lipoma*
	Fibroma
	Neurogenic tumours
	Pleomorphic adenoma
	Mucus gland adenoma
	Oncocytoma
	Tracheobronchopathia osteochondroplastica
Extrinsic compression	Lymphadenopathy
	Broncholithiasis
	Fibrosing mediastinitis
	Thyroid disease
	Goiter
	Cysts
	Thyroiditis
	Vascular disease
	Right aortic arch
	Double aortic arch
	Pulmonary artery sling
	Left carotid artery anomaly
	Aortic Aneurysm
	Mediastinal Cyst
	Abnormalities of the chest wall and spine
	Kyphoscoliosis
	Pectus excavatum
	Straight back syndrome
Infectious disease	Virus
	Bacteria
	Mycobacterium
	Mold
	Parasite
Dynamic expiratory narrowing	Tracheobronchomalacia
	Excessive dynamic airway collapse
Post-surgery	Anastomotic surgery
	Post pneumonectomy syndrome

THERAPEUTIC BRONCHOSCOPY

Therapeutic bronchoscopy is performed for central airway stabilization in airway obstruction and assessment for resection. Obstruction cases that are unresectable by therapeutic bronchoscopy are an option for palliative or definitive therapy to improve the quality of life and prolong the patient's life. Airway prosthetics that can be applied in bronchoscopy include silicone/ metallic stents, dilators, and laser invasive procedures. (Algorithm for the management of benign and malignant BCAO in Figure 2).[8–10]

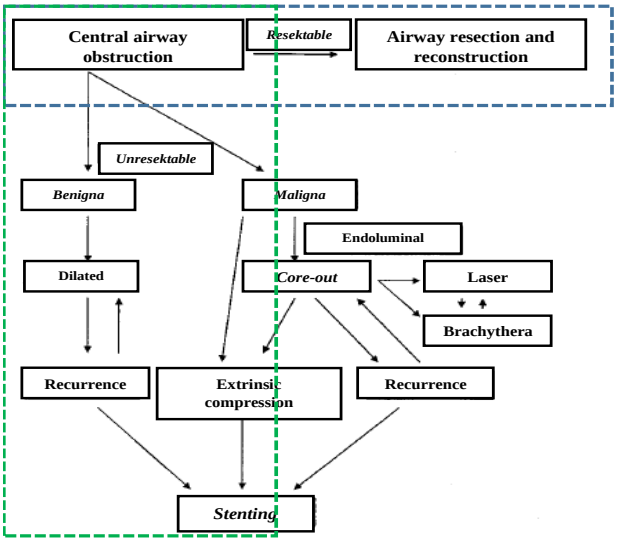

Figure 2. Algorithm for the management of CAO with therapeutic bronchoscopy. The box with dotted lines shows the management flow of BCAO.[10]

Stent

Installation of a stent with a rigid bronchoscope is usually performed under general anesthesia with or without muscle relaxants. While using a flexible bronchoscope, the patient may be subjected to local anesthesia and sedation. General anesthesia using induction of fentanyl 2.5ug/kg BW and propofol 2.0mg/Kg BW followed by maintenance with propofol 7–8mg/kg BW/hour reduced to 5–6mg/kg BW/hour after 15 minutes.[6,9,10]

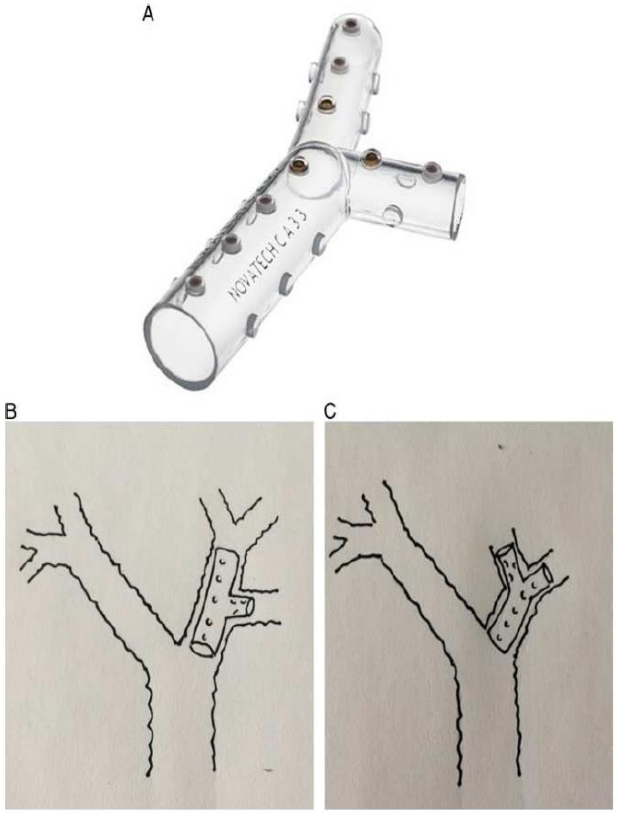

Figure 3. Ochy stent inserted into the right main bronchus: (A) Oki stent (Novatech), (B) Oki stent branching in the Upper-division, (C) Oki stent inserted into the right main bronchus, post-lobectomy. The right main bronchus appears to be shorter.[14]

There are 2 types of stents, namely silicone and metallic. Each type of stent is used depending on the case of stenosis and its cause. In cases of malignancy, metallic stents are often chosen to prevent tumor growth into the intraluminal, which are difficult to remove and have low migration incidence. Metallic stents are covered (silicone or polyurethane sheath) and uncovered. Examples of metallic stents are ultra-flex, wall stent and Silmet for straight shapes; Metallic Y-stents such as Ecostent. For the case of BCAO, the use of metallic stents should be avoided due to higher complications and difficult to remove. Silicone stents are recommended for OSNSJ since they are easy to remove, reposition, and cost less than metallic stents. Types of silicone stents such as Dumon and Spigots stents are easily detected by radiology because the base material is radio-opaque (Figure 3).[6,10–13]

Stent placement is performed by first determining the stent diameter and length covering the healthy areas proximal and distal to the stenosis, each about 5–10 mm. The type of stent used must be adjusted to the anatomic location, type of stenosis, underlying disease and risk of complications. Bronchoscopy experience helps in establishing the required stent diameter and length. Rigid diameter bronchoscopes may help in determining the diameter of stent. Generally, stents with a 14–16 mm diameter are used for tracheal stenosis and 10–12 mm for stenosis in the main bronchus.[3,6,10,13]

Amount 24 hours post stent placement, bronchoscopy was performed to assess the position of stent and complications that occurred. Subsequent monitoring is adjusted to the underlying disease. Nebulization with normal saline is recommended to maintain airway hydration and prevent mucus plugs and secondary infection due to impaired airway clearance function after stent placement. Corticosteroids and antibiotics are recommended for 3–4 days after stent placement.[6,10]

Balloon Dilatation

Evaluation bronchoscopy was performed for inspection and measurement, and then serial dilation was performed with a larger bronchoscope. The blunt tip Jackson bronchoscope reduces mucosal trauma and the risk of tracheal or bronchial perforation. The procedure is repeated by using a larger bronchoscope until an adequate airway calibre is achieved. If the lesson narrows for applying the 3.5 mm Jackson bronchoscope, esophageal bougies (flexible Jackson) are used to enlarge the airway or bronchoscopic dilatation. Pneumatic or hydrostatic pressure balloon dilation angioplasty is used occasionally. If a dilation is greater than 8–9 mm, dilation bronchoscopy is required (Figure 4). [6,8,9,15]

Core-out

At the time of initial examination, the intraluminal mass was assessed to determine tumor size and distal tracheal anatomy. A bronchoscope is used to compress the mass to maintain airway patency and evaluate the extent of pathological lesions. Mechanical removal of the tumor was performed with a rigid bronchoscope tip and continued debridement with biopsy forceps. Control bleeding with suction periodically. If the bleeding does not stop, laser and cryotherapy may be performed.[1,4,9]

Laser ablation

Benign endobronchial tumors are sometimes subjected to laser procedures according to multidisciplinary joint decision. Laser vaporization is performed for residual endobronchial tumors after mechanical core-out, tumors that are not amenable to mechanical debridement, and airway granulation management.[16] An Nd: YAG laser (MBB-AT Medilas 2 Nd: YAG 621, MBB-Angewandte, Munich, Germany) was used with a power setting of 35 watts and a pulse duration of 0.5 seconds.[9,14,17]

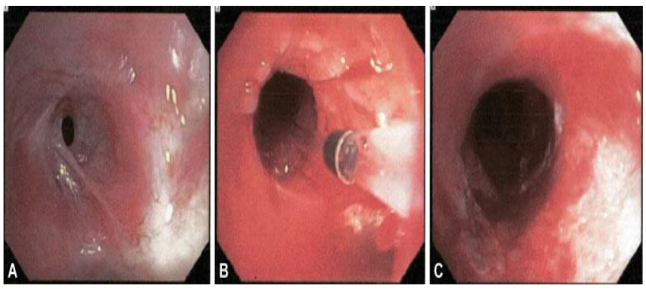

Figure 4. Granulomatosis polyangiitis (GPA) patient: (A) Bronchoscopic view of severe stenosis of the left main bronchus, (B) Post-treated airways with a radial cut followed by balloon dilation, (C) Left main bronchus diameter was significantly widened after ballooning dilation.[6]

CONCLUSION

Central airway obstruction is a respiratory emergency that requires immediate management. Benign central airway obstruction caused by infection, extrinsic compression, benign endobronchial tumors and dynamic airway wall abnormalities. Management requires a joint decision of multidisciplinary including pulmonary intervention, thoracic surgery, anesthesiologist and radiology. Bronchoscopy is a diagnostic and therapeutic modality for managing benign central airway obstruction and treating the underlying disease. Therapeutic bronchoscopy for managing benign central airway obstruction includes balloon dilatation, stent and laser.

REFFERENCES

1. Mitchell PD, Kennedy MP. Bronchoscopic management of malignant airway obstruction. Adv Ther. 2014;31(5):512–38.
2. Lawrence DA, Branson B, Oliva I, Rubinowitz A. The wonderful world of the windpipe: a review of central airway anatomy and pathology. Can Assoc Radiol J J Assoc Can Radiol. 2015;66(1):30–43.
3. Murgu SD, Egressy K, Laxmanan B, Doblare G, Ortiz-Comino R, Hogarth DK. Central Airway Obstruction: Benign Strictures, Tracheobronchomalacia, and Malignancy-related Obstruction. Chest. 2016;150(2):426–41.
4. Alraiyes AH, Machuzak MS. Rigid Bronchoscopy. Semin Respir Crit Care Med. 2014;35(6):671–80.
5. Oberg CL, Holden VK, Channick CL. Benign Central Airway Obstruction. Semin Respir Crit Care Med. 2018;39(6):731–46.
6. Holden VK, Channick CL. Management of benign central airway obstruction. AME Med J. 2018;3:76–76.
7. Buitrago DH, Wilson JL, Parikh M, Majid A, Gangadharan SP. Current concepts in severe adult tracheobronchomalacia: evaluation and treatment. J Thorac Dis. 2017;9(1):E57–66.
8. Kim H. ES 07.03 Bronchoscopic Management of Central Airway Obstruction. J Thorac Oncol. 2017;12(11):S1626–7.
9. Batra H, Yarmus L. Indications and complications of rigid bronchoscopy. Expert Rev Respir Med. 2018;12(6):509–20.
10. Chen DF, Chen Y, Zhong CH, Chen XB, Li SY. Long-term efficacy and safety of the Dumon stent for benign tracheal stenosis: a meta-analysis. J Thorac Dis. 2021;13(1):82–91.

11. Oda N, Sakugawa M, Hosokawa S, Fukamatsu N, Bessho A. Successful Long-term Management of Two Cases of Moderate Hemoptysis Due to Chronic Cavitary Pulmonary Aspergillosis with Bronchial Occlusion Using Silicone Spigots. Intern Med. 2018;57(16):2389–93.
12. Xu J, Ong HX, Traini D, Byrom M, Williamson J, Young PM. The utility of 3D-printed airway stents to improve treatment strategies for central airway obstructions. Drug Dev Ind Pharm. 2019;45(1):1–10.
13. Ayub A, Al-Ayoubi AM, Bhora FY. Stents for airway strictures: selection and results. J Thorac Dis. 2017;9(Suppl 2):S116–21.
14. Dalar L, Abul Y. Safety and Efficacy of Oki Stenting Used to Treat Obstructions in the Right Mainstem Bronchus. J Bronchol Interv Pulmonol. 2018;25(3):212–7.
15. Fang Y, You X, Sha W, Xiao H. Bronchoscopic balloon dilatation for tuberculosis-associated tracheal stenosis: a two case report and a literature review. J Cardiothorac Surg. 2016;11(1):21.
16. Elhidsi M, Zaini J, Ghanie A, Huswatun AL, Beginta R, Mety SH, et al. Therapeutic bronchoscopy followed by sequential radiochemotherapy in the management of life-threatening tracheal adenoid cystic carcinoma: a case report. J Med Case Reports. 202216(1):243.
17. Lee BR, Oh IJ, Lee HS, Ban HJ, Kim KS, Kim YI, et al. Usefulness of Rigid Bronchoscopic Intervention Using Argon Plasma Coagulation for Central Airway Tumors. Clin Exp Otorhinolaryngol. 2015 Dec;8(4):396–401.