

Initial Experience of Endobronchial Silicon Stents from a Tertiary Care Centre in North India

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ABSTRACT

Background. Central airway obstruction (CAO) is defined as obstruction of trachea and principal bronchi. Therapeutic rigid bronchoscopy with tracheobronchial stenting using silicon stents is a well established procedure in the management of such conditions. However, there is limited experience with this technique in India.

Methods. Between January 2010 and April 2010, Dumon stents were placed in four patients with CAO. Three patients had symptomatic tracheal stenosis while one patient had malignant obstruction at the carina. Rigid bronchoscopy under general anaesthesia was performed to relieve the CAO followed by placement of silicon stents. Pre- and post-stent placement symptom assessment was performed with a symptom-based visual analogue scale.

Results. Four patients underwent silicon stent placement in the tracheobronchial tree. Three patients had benign post-intubation tracheal stenosis and one had malignant tracheal obstruction at carina due to endobronchial growth. Significant improvement was achieved in all patients. There were no significant complications.

Conclusions. Rigid bronchoscopy with silicon stent placement is an effective and suitable method of relieving the distressing symptoms due to benign or malignant airway obstruction. [Indian J Chest Dis Allied Sci 2011;53:93-98]

Key words: Interventional pulmonology, Bronchoscopy, Stents, Lung cancer, Tracheal stenosis, Central airway obstruction.

INTRODUCTION

Central airway obstruction (CAO) is defined as obstruction of major airways, namely, the trachea and the main bronchi. In adult patients, CAO can occur due to several benign and malignant aetiological causes. CAO due to benign lesions usually arises secondary to tracheal stenosis as a complication of endotracheal intubation, tracheostomy, and airway trauma. It can also occur secondary to benign tumours, tracheobronchomalacia, or at the anastomotic site in subjects undergoing lung transplantation.^{1,2} Likewise, luminal obstruction by an endobronchial growth or extrinsic compression caused by bulky lymph nodes most commonly produces CAO due to malignant diseases. Benign and malignant CAO presents with disabling consequences of dyspnoea, stridor and obstructive pneumonia.

Segmental tracheal resection with end-to-end anastomosis is the preferred treatment for benign

stenosis.³ On the other hand, interventional pulmonology is the preferred approach in the management of malignant CAO. The surgical approach is not only limited by concomitant medical conditions and operability but also surgery is associated with recurrence of stenosis and difficulties at the site of the anastomosis. Hence, bronchoscopic intervention is an important complementary therapeutic strategy.

Rigid bronchoscopy with tracheobronchial stenting using silicon stents is a well-established procedure in the management of such conditions. In last two decades, advances in the interventional bronchoscopy as well as improvement in the stent design have extended the use of bronchoscopically deployed metallic and silicon stents in the management of tracheobronchial obstruction. The efficacy of silicon stents in terms of symptomatic relief and objective improvement in pulmonary function after its insertion has already been highlighted in the published literature.⁴⁻⁶ *However, to the best of our*

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knowledge, its use in the Indian subcontinent has not been previously reported. Herein, we report our experience with the use of studded silicon stents for a variety of obstructive tracheobronchial lesions causing CAO.

MATERIAL AND METHODS

The first four patients undergoing silicon stent placement at our centre between January 2010 and April 2010 were reviewed. A written, informed consent was obtained from each patient before the procedure. Prior to the procedure, the severity and aetiology of CAO was evaluated by chest radiography, computed tomography (CT) of the chest including 3D reconstructions, and bronchoscopy. Pre- and post-procedure symptoms were assessed on a visual analogue scale from 0-100mm (0=no improvement; 100=complete relief).

All procedures were performed under general anesthesia (GA). Patient was pre-oxygenated for a minimum of three minutes to compensate for the apnoeic period during intubation with rigid bronchoscope. Anaesthetic induction was performed with intravenous propofol and fentanyl that permitted continued spontaneous ventilation by the patient. This was followed by intravenous succinylcholine to achieve neuromuscular blockade. After intubation with rigid bronchoscope the patients were maintained with a combination of intravenous propofol and atracurium/vecuronium and ventilated through the ventilation port of the rigid bronchoscope. Reversal of neuromuscular blockade was achieved with neostigmine and glycopyrrolate.

Rigid Bronchoscopy

Instrument Assembly. Rigid bronchoscopy was performed with the 6.5mm to 14mm internal diameter (ID) Storz bronchoscope (Karl Storz GmbH and Co., KG, Germany). Endoscopic magnification was provided by a telescope (Hopkins straight-forward telescope; Karl Storz GmbH and Co., KG, Germany) attached to a video monitor to provide visualisation for the whole procedure. Rigid bronchoscope with corrugated ventilation adapter and Hopkin's telescope was held in the right hand keeping the distal flared lip or shovel portion anteriorly. Image of the distal portion of the scope was oriented in a manner to ensure the protruding distal lip is at the 12 'o'clock position. The telescope was fixed in the bronchoscope with the right hand to keep the distal end of the telescope inside the bronchoscope for proper insertion.

Bronchoscopic Procedure. With patient properly relaxed, a rigid pillow was placed under the

occiput, the neck was extended and head was positioned in a manner so as to keep the chest wall and the tragus of the external ear at the same level. This brings the oral cavity, oropharynx and vocal cords in a straight line. Second, third and fourth fingers of the left hand were then inserted into the mouth to allow the positioning and stabilisation of the head during the intubation. Lower and upper teeth and lips were protected using index finger and the thumb which also served as a guide to insert and pass the bronchoscope through the oropharynx.

The bronchoscope was held perpendicular to the mouth and passed through the tunnel of the forefinger and the thumb to visualise the uvula. Upon reaching the uvula the bronchoscope was angled downwards to bring the orientation of the long axis of the tube horizontally using thumb as a fulcrum guided anteriorly by the index finger. While slowly advancing the scope past the uvula and maintaining the protruding lip at 12 'o'clock epiglottis was elevated and passed under it to approach the vocal cords. At vocal cords, the bronchoscope was rotated 90° to pass the lips of the scope through the vocal cords by gently pushing between the cords. After passing the distal lip past the vocal cords, bronchoscope is rotated back to its normal position to place the distal protruding lip at 12 'o'clock position. At this stage, the anaesthetist ventilated the patient through the ventilating channel of the bronchoscope. The scope was further advanced into the trachea for visualisation.

Dilation of the Stenotic Segment. The stenotic segment was mechanically dilated directly with increasing sizes of the rigid bronchoscope applying rotating pressure and firmly negotiating the stenotic segment. If the stenotic segment could not be manipulated through the rigid bronchoscope then a rapid balloon bronchoplasty was performed as detailed below.

Mechanical Debridement. Endobronchial tumour was debulked by the mechanical core-out of tumour using the bevel of the rigid bronchoscope followed by the retrieval of the debrided mass with the help of telescope enabled biopsy forceps. Epinephrine solution (2mg epinephrine in 500mL saline solution) was used to achieve adequate haemostasis during the coring of the mass.

Balloon Bronchoplasty

Balloon dilatation of the stenotic segments was performed by the controlled radial expansion technique using 5.5cm length wire guided balloons (CRE™, Boston Scientific, US) with sequentially larger diameter. The balloon was filled with saline until full deployment is reached with the help of a pressure-measuring syringe (Alliance II™ 60mL

Single-Use Syringe/Gauge Assembly; Boston Scientific, US), to a pre-specified burst pressure ranging from 6 to 10 atmospheres (depending on the balloon size) to attain an inflation diameter ranging from 8mm to 15mm. Each dilation was maintained for 45 to 60 seconds and repeated two times, with sequentially larger diameter balloons.

Stent Deployment

The stents were molded silicon rubber with external studs except along the posterior wall to engage the airway and avoid dislodgment. Absence of studs at the posterior aspect of the stent wall facilitates orientation. Silicon tracheal stents of 16mm or 18mm in diameter and 50mm to 60mm in length (when fully expanded) were used for the post-intubation benign tracheal stenosis. Silicon Y-stent having a proximal tracheal limb of 18mm diameter and 60mm length and a bilateral mainstem bronchial limb diameter of 14mm was used for the malignant tracheal/carinal obstruction which were predominately held in place by their geometry at the carina. The right main bronchial stent limb with a 15mm length and distal end beveled was placed to avoid the obstruction of orifice of the right upper lobe by a stent in the right mainstem bronchus (Figure 1).

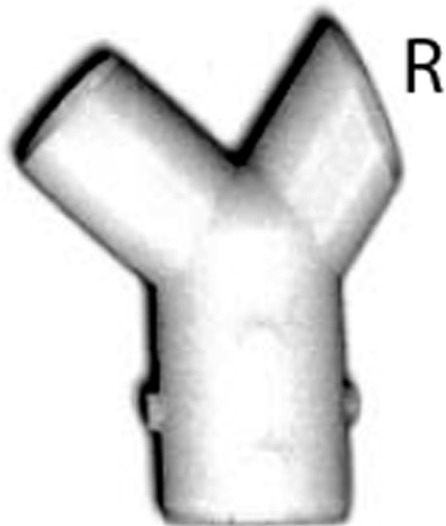


Figure 1. Silicon Y-stent with right limb cut obliquely to prevent occlusion of the right upper lobe bronchus.

Dilatation of the stricture was performed until a 14mm ID bronchoscope could be passed through the stenotic segment. The reason is that adult stents with a transverse diameter of 15mm or more require an applicator for placement which can only be passed through a 14mm ID bronchoscope. The length and diameter of the stent was decided based on the CT

and bronchoscopy findings with the stent being 15mm to 20mm above and below the lesion. Special attention was given to the relation of the lesion with vocal cords, carina and lobar orifices. The diameter of the stent was decided by the diameter of the trachea proximal to the lesion and the stent was chosen about 1mm to 2mm more than the diameter of the trachea. The silicon stent was loaded into a specifically designed introducer (Tonn tracheal and bronchial stent applicator, Novatech, France). The introducer was then passed through the rigid bronchoscope.

Y-stent can be deployed using the applicator through the rigid bronchoscope utilising either "pushing technique" whereby the stent was placed just above the carina and is then pushed forward with the open rigid forceps placed at the bifurcation of the stent; or the "pulling technique" whereby the stent is directly placed at one of the main bronchi and then pulled backwards using the forceps until the shorter of the limb slipped into the other bronchi.

Post-procedure Bronchoscopy

Fiberoptic bronchoscopy (FOB) was performed immediately and 24 hours after the stent placement in all the patients to evaluate the position and expansion status of the stent. All patients underwent chest radiography and clinical examination one to two days after stent placement to evaluate the status of the stent.

RESULTS

Four patients (mean age 36.5 ± 18.1 years) undergoing tracheobronchial stenting for CAO were included in this analysis. Three patients were diagnosed as having CAO due to benign post-intubation tracheal stenosis in the upper-third of the trachea and one patient had bronchogenic carcinoma in the lower-third of the trachea along with carinal involvement. Patients with tracheal stenosis did not manifest tracheomalacia indicating that the underlying cartilages were intact. Morphologically all lesions were circumferentially involving the trachea. Patient characteristics and clinical outcomes and the location of the obstruction are summarised in the table. All patients complained of dyspnoea, cough, and stridor at presentation. Technically successful stent placement could be done in all patients and this resulted in rapid improvement in dyspnoea immediately after the procedure. Rapid reversal of anesthesia and consciousness could be done in two patients. Two other patients who developed laryngeal and subglottic oedema during the procedure required mechanical ventilation for 12 to 18 hours, after which they were successfully extubated.

Table. Baseline characteristics, location of lesions and outcomes of four patients with central airway obstruction

| Patient No. | Age (years) | Gender | Aetiology | Stenosis | | Rigid Bronchoscopic Procedure | Balloon Bronchoscopic Dilation | Visual Analogue Scale (mm) | | Complications |
|-------------|-------------|--------|-----------------|-----------------------|-----------------------|-------------------------------|--------------------------------|----------------------------|----------------|-----------------|
| | | | | Diameter; length (mm) | Distance from VC (mm) | | | Pre-procedure | Post-procedure | |
| 1 | 20 | M | Post-intubation | 2; 13 | 45 | Dilatation | No | 45 | 95 | None |
| 2 | 25 | M | Post-intubation | 2; 28 | 50 | Dilatation | Yes | 55 | 100 | Stent migration |
| 3 | 41 | M | Post-intubation | 3; 20 | 50 | Dilatation | Yes | 10 | 100 | Stent migration |
| 4 | 60 | M | Lung cancer | Near total occlusion | 100 | Mechanical Coring | No | 70 | 100 | None |

M=Male; VC=Vocal cords

Fiberoptic bronchoscopy performed immediately after the procedure showed perfect placement of stents covering the stricture site. However, FOB after 12 hours revealed distal migration of stents in two patients. These stents were pulled proximally through rigid bronchoscope.

Patient 1. A 20-year-old male presented with stridor and had been intubated and mechanically ventilated for eight days following road traffic accident one month prior to presentation. FOB and CT revealed severe tracheal stenosis beginning 4.5cm distal to the vocal cords with a stricture involving approximately 90% of the tracheal diameter (Figures 2A and 3). Rigid bronchoscopy was performed and the stenosis was dilated with insertion of progressively increasing size of the bronchoscope beginning with the 6.5mm ID bronchoscope (Figure 2A). A studded Dumon silicon stent (16mm diameter, 50mm length) was placed through the bronchoscope and positioned 2cm below the vocal folds (Figure 3). The patient had an

uneventful recovery and was discharged two days after the procedure.

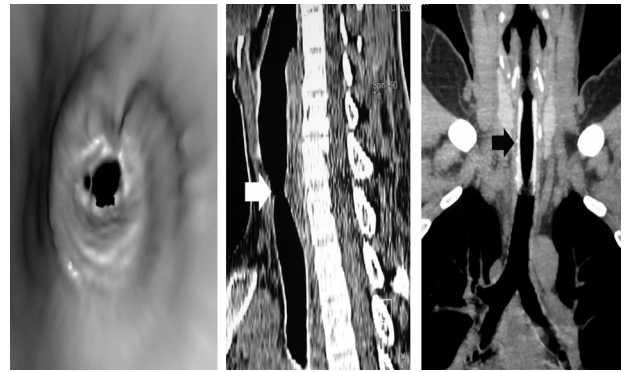


Figure 3. Computed tomographic images of the patient with tracheal stenosis. Virtual bronchoscopic image of the stenosis (right), sagittal view of the lesion (centre, solid row) and coronal view of the silicon stent in the trachea (left).

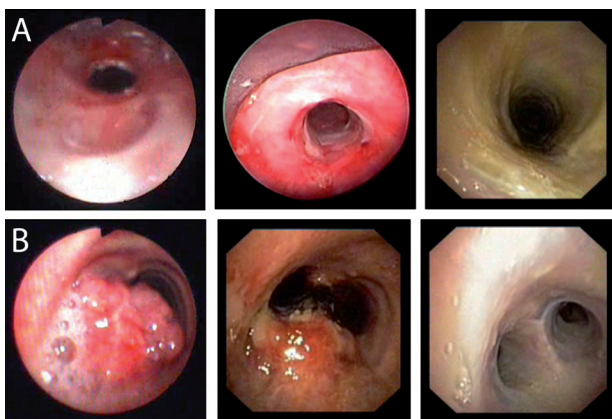


Figure 2. Bronchoscopic images of two patients, tracheal stenosis (A) and carinal growth (B). *Panel A:* tracheal stenosis occluding more than 90% of the lumen (right); stenosis following dilatation (centre); and, tracheal stent *in situ* (left). *Panel B:* growth in the lower trachea involving the carina and occluding more than 90% of the lumen (right); trachea following mechanical debriement with rigid bronchoscope (centre); and, y-stent *in situ* (left).

Patient 2. A 25-year-old male presented with dyspnoea and stridor. He had been intubated and mechanically ventilated for 12 days for pyogenic meningitis, three weeks prior to the presentation. FOB revealed severe tracheal stenosis beginning 5cm distal to the vocal cords with a stricture involving approximately 90% of the tracheal diameter. Rigid bronchoscopy was performed and the stenosis was initially dilated using the 6.5mm ID bronchoscope. Subsequently balloon bronchoplasty was performed and the stenosis dilated to 10mm. Then a 12mm bronchoscope was negotiated through the stenotic segment. Balloon bronchoplasty was again performed and the stenosis dilated to 15mm. Finally, a silicon stent (18mm diameter, 50mm length) was placed through the 14mm bronchoscope and positioned 4cm below the vocal folds. FOB, performed next day, showed distal migration of the stent exposing the stenotic segment. Under general anaesthesia, the stent was pulled towards the vocal cords to cover the stenotic segment. The patient recovered uneventfully and discharged two days after the procedure.

Patient 3. A 41-year-old male intubated and mechanically ventilated for six days following transhiatal oesophagectomy for carcinoma oesophagus (four months prior to presentation) presented with dyspnoea and stridor. FOB revealed severe tracheal stenosis beginning 5cm distal to the vocal cords with a stricture involving approximately 90% of the tracheal diameter. A combination of rigid bronchoscopy and balloon bronchoplasty was performed such that a 14mm bronchoscope could be negotiated through the stenotic segment. A Dumon silicon stent (18mm diameter, 50mm length) was placed through the 14mm bronchoscope and positioned 4cm below the vocal folds. FOB performed next day showed distal migration of the stent exposing the stenotic segment. Under general anaesthesia, the stent was pulled towards the vocal cord to cover the stenotic segment. The patient recovered uneventfully and discharged two days after the procedure.

Patient 4. A 60-year-old male presented with exertional dyspnoea. Chest radiograph was normal. CT chest revealed a growth in the lower-third of trachea (Figure 4). FOB showed growth in the lower-third of the trachea involving the carina (Figure 2B). It completely occluded the left main bronchus and more than 75% of the lumen of the right main bronchus. Rigid bronchoscopy was performed and mechanical debridement of the growth was done (Figure 2B). The length of left main and right main bronchus (proximal to the opening of the upper lobe bronchus) was measured. The Y-stent was then cut to the appropriate length with the limb of the right main bronchus cut diagonally so as to prevent occlusion of the right main bronchus. The stent was then successfully deployed using the 14mm bronchoscope and the Tonn applicator with the "pushing" technique. The stent was then stabilised using the biopsy forceps. Repeat FOB and CT showed perfect placement of the stent (Figures 2B and 4) and the patient was discharged three days after the procedure.

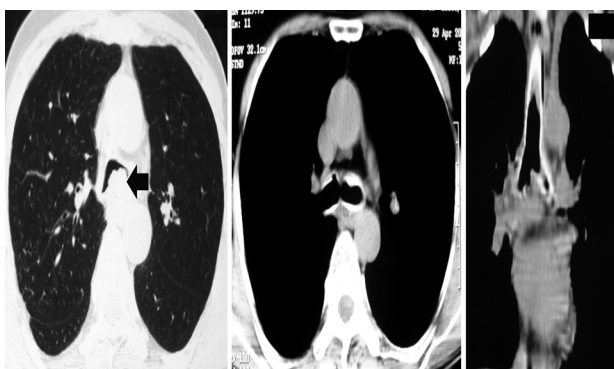


Figure 4. Computed tomographic images of the patient with lower tracheal growth. Lung window showing the lower tracheal and carinal growth (right), y-stent *in situ* (centre) and coronal view of the silicon y-stent straddling the right and left main bronchi (left).

DISCUSSION

Stent placement is generally divided into temporary and permanent stent implantation. Temporary stenting is done in curing stenotic lesions and stabilisation of tracheomalacia while definitive stent implantation is chosen in patients with severe comorbidities or in cases with advanced malignant airway obstruction. After a decade of T-tube airway stent by Montgomery for subglottic stenosis, Dumon revolutionised airway stenting by developing a dedicated endobronchial silicon stent that could be introduced with the rigid bronchoscope.^{5,7} These silicon stents with studs in the outer wall are relatively inexpensive and can be easily inserted and removed as and when required. Although surgical resection and reconstruction is considered the primary modality of choice for CAO, variety of factors like long segmental lesion, failed previous repair, metastatic or unresectable malignancy dictates an alternative approach, most commonly interventional bronchoscopy.⁸ The surgical approach is also limited by difficult local situations (e.g., critical stenosis where intubation is not feasible), and experience of the thoracic surgeon in the management of this life-threatening condition which is sparingly available across the country.

By providing rapid relief in symptoms, improved quality of life and time for chemoradiotherapy, airway stenting has emerged as a valuable adjunct in approximately 30% patients with lung cancer presenting with CAO secondary to endobronchial growth or external compression by a bulky or tumorous lymphadenopathy.^{4,9,10} However, bronchoscopic management of CAO is usually palliative and often requires repeated interventions to obtain or maintain an airway patency. Thus, these interventions should only be chosen when definitive surgical approach is not feasible or contraindicated.

Post-intubation tracheal stricture attributable to impaired blood flow caused by mucosal or full-thickness tracheal cuff pressure necrosis remains the main cause of tracheal stenosis, despite widespread use of low pressure/high volume cuffs.⁸ This was the aetiology in three of our patients. Staging of the tracheal stenosis can be done by using the Myer-Cotton system.¹¹ Myer-Cotton *et al*¹¹ staged tracheal stenosis depending upon the degree of stenosis as less than 50% (grade I), 51% to 70% (grade II), more than 70% with any detectable lumen (grade III); and airway with no lumen (grade IV). The patients in this series had luminal compromise of at least 90 percent. Also, all our patients had circumferential strictures that have been shown to be associated with poor outcome and require more aggressive intervention than the eccentric strictures.¹² Stenting after luminal dilatation with rigid bronchoscopy/balloon

bronchoplasty has been shown to be safe and effective in benign tracheal stenosis with feasibility of stent removal once the local and general conditions permit.¹³ Although six to eighteen months have been advocated for keeping the stent in place following its placement but the optimal duration is unknown.^{5,14,15} With time, stabilisation and resolution of stenosis occurs, thus, the duration depends upon the severity of the disease.

A wide variety of stents are available for endobronchial application which can be broadly grouped into tube stents, metallic stents, hybrid stents and dynamic stents.¹⁶ Tube stents are further sub-categorised as Montgomery T-tube, Dumon, Noppen, polyflex and hood. Major limitations of silicon tube stents are interference with mucociliary clearance, and a need for rigid bronchoscopy for their placement. Studs in the outer wall of the Dumon stents were designed to decrease the ciliary impairment.¹⁷ However, these stents are less useful in conditions like tracheobronchomalacia or to bridge tracheo-oesophageal fistula because they need adequate contact pressure between the airway wall and the studs to prevent its migration. By virtue of its easy application with FOB under local anaesthesia, metallic stents are ideal but granulation tissue formation within the stent and practical difficulty with its repositioning and removal limits its widespread use in benign conditions. Hybrid stents are made up of silicon with metal ring reinforcement. Similarly, dynamic stents has silicon tube with horse-shoe shaped metal ring in the anterior part and soft posterior wall similar to membranous trachea.¹⁶ Commonly encountered complications of Dumon silicon stents are migration (5% to 13%), granuloma formation (1% to 8%) and mucus plugging (2% to 4%) at the site of application.^{9,18,19} Moreover, these complications are more commonly seen with benign lesions than with malignant lesions.^{19,20} We noted stent migration in two of our patients, which were successfully repositioned.

In conclusion, all patients in this series with tracheobronchial obstruction respond well to bronchoscopic silicon stenting with improved quality of life and survival. However, it is unwise to expect endobronchial stenting can replace airway resection and reconstruction as a definitive management of benign and malignant airway lesions, but it does offer immediate palliation of respiratory symptoms with an improved quality of life and frequently length of life as well. Also, it is the definitive management in situations where surgery cannot be performed or there is lack of surgical expertise in performing tracheal procedures.

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