Abstract

Introduction: Tracheal stents are deployed to attenuate intrinsic or extrinsic airway compression. They remain the gold standard for management of airway stenosis, especially when surgical resection is contraindicated. This study aimed to determine whether stent placement, by either fluoroscopic guidance or rigid bronchoscopy, resulted in improved procedural outcomes.

Methods: We compared two techniques of tracheal stent insertion and their associated complications. Method one involved insertion of stent under fluoroscopic guidance, while Method two involved placement with rigid bronchoscopy under direct vision. Both techniques require pre-operative airway assessment with Computed Tomography imaging, but require different anesthetic intervention. Data from patients receiving stent insertion over a period of 4 years, at either Nepean Hospital or Beaumont Hospital, was assessed.

Results: Both techniques enabled appropriate stent placement, resulting in patent airways and attenuation of dyspnea. Rigid bronchoscopy is advantageous in a setting lacking intraoperative image intensifier or flexible bronchoscopy; however insertion of stents under fluoroscopic guidance enables management of more distal stenosis, an area of challenge for rigid bronchoscopy.

Conclusion: Tracheal stenting can be performed via different techniques with similar results in patient outcomes. We demonstrate that tracheal stenting via rigid bronchoscopy can be successfully performed to provide patients with patent airways in the emergency setting and may represent a more viable option in facilities lacking intraoperative image intensifier or flexible bronchoscopy.

INTRODUCTION

Stenting is an effective therapeutic measure to attenuate airway compromise in the setting of luminal disease, extrinsic compression or dynamic collapse of the trachea. Restoring airway caliber significantly improves the passage of air into the lungs, reducing dyspnea, mechanical work of breathing and risk of obstruction; greatly improving patient quality of life.

Stenting also reduces patient morbidity. Previously, surgical intervention for tracheal stenosis involved resection and re-anastomosis, known to be associated with significant risk of complication [1]. Stents are also a safer alternative to tracheostomy, especially if the malignancy is localized to the infracricoid region. They are also rapidly sited, reducing operative time in unstable patients and are optimal as a minimally invasive technique in the setting of palliation [2]. Tracheal stent insertion is the modality of choice for managing patients with difficult airway stenosis where resection is contraindicated, as they have the capability to provide a patent airway while preserving phonation function [3]. Sheathed tracheal stents also improve airway patency in patients suffering from tracheal fistulas [4].

Advances in stent design has resulted in a variety of insertion techniques, decreased complications and enabled the completion of concurrent interventions, namely tissue debulking by laser, electrocautery, cryotherapy, photodynamic therapy, brachytherapy or chemoradiotherapy [5].

There are many indications for tracheal stenting. It can

be utilized to abrogate almost all causes of airway narrowing, including malignant tracheobronchial obstruction or subglottic stenosis (due to prolonged endotracheal intubation), tracheostomy, radiation therapy, relapsing polychondritis or granulomatous disease. It has been successfully deployed for inhalation injury [6], anastomotic stricture or dehiscence post lung or heart - lung transplant, tracheosophageal or bronchopleural fistula [7], tracheobronchial malacia and idiopathic or congenital airway stenosis. Tracheal stents can also be implanted for airway stenosis secondary to extrinsic compression.

This study examined two methods of tracheal stent insertion and assessed post-operative outcomes within the patient cohort. We demonstrate that both rigid bronchoscopy and fluoroscopic guided siting provides a satisfactory attenuation of airway obstruction. However, both techniques differ in anesthetic technique, equipment required and effective placement in certain regions of the tracheobronchial tree.

METHODS

A retrospective assessment of patients who received tracheal stenting was performed. Informed consent was obtained from all patients (or their next of kin) prior to stent placement. Comparative data was obtained from Nepean Hospital (a tertiary referral center, affiliated with the University of Sydney), Sydney, Australia or Beaumont Hospital (a tertiary referral center, affiliated with the Royal College of Surgeons), Dublin, Ireland. The procedures were performed by a Specialist Surgeon at each respective Hospital or by the visiting Otolaryngology Head and Neck fellow, who was affiliated with both Hospitals.

Preoperative assessment

Preparation for surgical intervention involved a multidisciplinary team approach, with each case being presented within a forum consisting of an Otolaryngology, Head and Neck Surgeon or Cardiothoracic Surgeon, Anesthetist, Radiologist and Respiratory Physician. High resolution computed tomography imaging in conjunction with delivery of iodiine contrast material provided important information about airway anatomy and potential lesions. Specifically, proximity to the vocal folds, length of lesion/stricture and diameter of the trachea were measured to enable optimal selection of stent. Imaging was also carefully assessed for evidence of pulmonary artery invasion in the setting of bronchial malignancies.

Stent

An ultraflex tracheobronchial stent (Boston Scientific, Natick, MA, USA); a tightly woven, self-expandable metallic stent (composed entirely of a single strand of nickel - titanium alloy), was utilized for all patients (in both centers). Central airway stenosis was evaluated using chest CT and bronchoscopy. The choice of stent length, diameter and type (sheathed or unshathed) was determined intraoperatively, taking into consideration the CT findings and endoscopic examination. Stent sizes ranged from (10 mm x 20 mm) to (20 mm x 40 mm).

Anesthesia

Anesthesia differs significantly between the two methods of stent placement. Stent delivery by fluoroscopic guidance involves insertion of an endotracheal tube under direct laryngoscopy (commonly by the attending anesthetist). This allows the introduction of a flexible bronchoscope through the endotracheal tube into the trachea- enabling visualization of the stenosis and placement of stent. Stent delivery by rigid bronchoscopy utilized a Hunsaker Mon-Jet tube with jet ventilation. This small tube provides sufficient patient ventilation during instrumentation and delivery of stent to the stenosis.

Fluoroscopic guided technique

Initial examination of the airways was performed with a flexible bronroscope. Fluoroscopic imaging enabled demarcation of stricture or tumor location, afterwhich its dimensions were marked externally, with particular attention to proximal and distal limits. The distance from the vocal folds was also defined. A Seldinger technique (guidewire down the bronchoscope and through the lumen of the obstructed airway) was employed to enable stent delivery over the guidewire to the demarcated territory with subsequent deployment. Post-procedural bronchoscopy clarified appropriate placement and airway patency.

Direct Laryngoscopy with Rigid Bronchoscopy

A Lindholm or Kliensasser laryngoscope was utilized to visualize the vocal folds and enable entry of a long 4mm, 0-degree endoscope into the trachea. The Hunsaker Mon-Jet tube was positioned to ventilate, and the stent introducer was inserted into the trachea, through the lumen of the obstruction and deployed under direct vision. This technique allows manipulation of the stent after deployment and thorough assessment of distal airways post placement.

RESULTS

Patients from Nepean Hospital – Fluoroscopic guidance

During a defined period (1st of May, 2010 to 1st of December, 2012), 10 patients received 12 tracheal stents (mean age ± standard deviation, 63 ± 9.4; range, 49 - 84) using fluoroscopic guidance (Table 1). A mixture of sheathed and unshathed self-expanding metallic stents was utilized. All patients complained of dyspnea, immediately relieved by intervention. 6 patients presented with obstruction secondary to tracheobronchial malignancy (both primary and secondary cancers). 2 patients had extrinsic compression, one from mediastinal lymphadenopathy secondary to small cell lung cancer and one from thyroid goitre. One patient had tracheal stenosis secondary to prolonged tracheostomy, and one patient required a tracheal stent for repair of an anastomotic leak post tracheal resection, which was later removed (Table 1). Of these stents, 7 were placed in the trachea (in 5 patients, 2 of which required another stent) and 5 into the main bronchus or lobar/intermedius bronchi (Table 2).Three patients required stent revision. A 68 year old male required revision 1-month post insertion secondary to strenuous coughing. Stent migration precipitated revision in a 49 year old male four days after insertion, while a 60 year old female with a significant bronchial tumor occlusion required a second attempt which was unsuccessful secondary to tumor progression (Table 2). Four of the given patients with intraluminal lesions
Table 1: Indications for Stent placement.

<table>
<thead>
<tr>
<th>Indication</th>
<th>Fluoroscopy (Nepean Hospital)</th>
<th>Laryngoscopy (Beaumont Hospital)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malignancy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tracheobronchial SCC</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Oesophageal SSC</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Oesophageal SSC with Fistula</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Lung Carcinoma</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Metastatic Breast Cancer</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Tracheal stenosis</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Extrinsic Compression</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thyroid goitre</td>
<td>1</td>
<td></td>
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<tr>
<td>Lymphadenopathy</td>
<td>1</td>
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<tr>
<td>Lymphoma</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Anastomatic dehiscence</td>
<td>1</td>
<td></td>
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</tbody>
</table>

Table 2: Operative differences and complications of both techniques.

<table>
<thead>
<tr>
<th></th>
<th>Fluoroscopy (Nepean Hospital)</th>
<th>Laryngoscopy (Beaumont Hospital)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative Time (mins)</td>
<td>38.9</td>
<td>56.6</td>
<td>0.19*</td>
</tr>
<tr>
<td>Location of Stenosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trachea</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Bronchus</td>
<td>5</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Complications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stent migration</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Restenosis</td>
<td>5</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Operative time is average time in minutes
* t test used to compare operative time, not statistically significant

had successful tracheal debridement, or argon beam ablation, for recurrence of disease.

Patients from Beaumont Hospital – Rigid Laryngoscopy and Telescopic Visualization

During a defined period at the Beaumont Hospital (2009-2012), six patients received tracheal stents (mean age: standard deviation, 66.6 ± 8.2; range, 54 - 78), with only one of these patients requiring revision (Table 1). Sheathed, metallic stents were utilized in all patients. One patient was suffering from lymphoma, while the other 5 had intraluminal tracheal stenosis secondary to carcinoma, one patient also having a tracheobronchial fistula (Table 1). All patients had reversal of their acute respiratory symptoms post-operatively. One patient required a return to the operating theatre the same day for a further stent placement due to stent expulsion (sten failed to deploy appropriately) (Table 2).

DISCUSSION

Tracheal stenting is an efficient and effective measure to alleviate clinical symptoms associated with airway occlusion, namely dyspnea, hemoptysis and persistent obstructive pneumonitis. It is the gold standard for management of unresectable tracheal malignancy and may be utilized as a neoadjuvant procedure prior to radiation therapy [1]. Walser (2005) identified that 82-97% of patients undergoing stenting reported improvement in dyspnea and quality of life [2]. A challenging situation is the palliative patient intubated in the acute setting with airway obstruction. Stenting allows these patients to be extubated and provides phonation- a highly important function [8]. Importantly, stents are suitable for both adults and pediatric populations [9, 10].

This study corroborates literature demonstrating the benefit of stenting in acute management of central airway stenosis. Although this investigation contains a small cohort of patients (n=16, n=19 stents), it also demonstrates that stent delivery is not technique dependent- an important finding for health care facilities with limited access to interventional equipment.

However, method of stent delivery is dependent upon the site of stenosis within the tracheobronchial tree. A limitation of the Direct Laryngoscopy with rigid bronchoscopy technique is access to occluded distal airways, anatomy which is more effectively accessed with flexible techniques under fluoroscopic guidance. In spite of this, Rigid Bronchoscopy does provide the Surgeon and Anesthetist with continuous visualization of the airway, allowing them to work together. This creates the ideal environment for teaching and video documentation of the procedure. Lesions can be assessed in detail and in the event of intraoperative hemorrhage or complication, instrumentation is possible. This technique also enables easy manipulation of the stent after deployment if re-positioning is required and reduces time, exposure to radiation and resources required to complete the procedure, issues associated with fluoroscopic delivery and utilization of image intensifier.

With the market providing a diversity of stent options; lesion type, location and physical characteristics of the stent, as well as the potential short and long term complications need to be considered when selecting the appropriate stent for deployment. This study utilized both a sheathed and unsheathed metallic stent. As outlined in Table 2, complications with stent migration and restenosis occurred in both methods of stent delivery. An important benefit of stenting in general is that these complications were rectified effectively with revision stenting (except for one patient who had a complete right intermedius bronchial in-stent re-stenosis and revision stenting failed).

Stent migration can be a significant issue. It is commonly caused by persistent cough (an unfortunate side effect of tracheobronchial irritation), tumor growth or change in extrinsic compression reducing pressure applied to the airway. Tracheobronchial migration is frequently reported complication, occurring in up to a quarter of cases [11]. It is more common with silicone than metal stents. In an attempt to overcome this issue, interventionists have attempted both internal [12] and external [13] suture fixation of silicone stents in the subglottic region, but these techniques are rarely utilized, potentially due to ease of revision. 3 patients (2 from the fluoroscopic group and 1 from the endoscopic, laryngoscopy group) from our series experienced stent migration and had successful succeeding procedures to reposition the stent.
Restenosis remains a problematic long-term complication of tracheal stenting. Commonly restenosis is caused by fibrosis, granulation tissue, tumor invasion/ recurrence and accumulated respiratory secretions. Local inflammatory reaction causes fibrosis or granulation tissue in growth at the ends of the stents. This is more commonly reported in the metal stents requiring additional endoluminal procedures [2]. Ko et al (2009) demonstrated that the distance between the tracheal stent and the vocal cords was inversely correlated with severity of granulation formation. They found that stents placed less than 1 cm to the vocal cords were highly likely to precipitate granulation stenosis.

Coverage of respiratory epithelium and subsequent breach of the mucociliary escalator results in accumulation of respiratory secretion in the stented segment. This complication is seen more frequently with the silicone or sheathed stents. Tumor recurrence may also cause restenosis. This occurred in 4 of our patients who subsequently underwent flexible bronchoscopies, with argon beam tumor ablation with effective control of the tumor tissue and attenuation of clinical symptoms.

Other complications of stent placement have been described and were not encountered by this study. These include: stent fracture and erosion of stents into major blood vessels, resulting in hemoptysis. For example, the Giantourco stent has been associated with an increased incidence of bleeding complications, speculated to be secondary to its rigidity [14, 15]. Major hemoptysis has been documented in cases of stent application for airway stricture due to extrinsic compression from aortic aneurysms or congenital aortic arch anomalies [16]. It has also been described in a case from penetration of the membranous trachea and erosion of the thyroid artery resulting in dramatic hemoptysis and death [9]. Stents placed over and above the vocal cords into the supraglottic territory are associated with high risk of aspiration [67%] [3].

We recommend jet ventilation as the method of anesthetic delivery for stent insertion via Direct Laryngoscopy and Rigid Bronchoscopy, as it allows for an unobstructed view of the airway. Jet ventilation is the delivery of gas, under high pressure through a small catheter into the airway, either at the supraglottic or subglottic level, therefore providing surgical access and decreases the concern of airway fire with laser use. High-frequency jet ventilation is the delivery of small tidal volumes at frequencies jet ventilation is the preferred anesthetic approach for management of central airway obstruction [17,18]. Other techniques also provide adequate airway ventilation such as endotracheal intubation, rigid bronchoscopy ventilation, inhalation induction with spontaneous breathing and laryngeal mask as previously reported [18, 19].

Consequently, individual patient assessment is important and all factors must be considered when selecting the most appropriate type of stent, technique and mode of anesthetic for each case. For stenosis in the trachea, both methods described provide adequate placement of tracheal stents (except for insertion of silicone stents, which can only be placed with rigid laryngoscopy). In cases where the stenosis is in the distal airways, we recommend stent deployment with fluoroscopic guidance.

In stating this, a limitation of this study is the small cohort size; consequently caution should be taken when generalizing these findings.

**CONCLUSION**

Tracheal Stents are an effective measure to attenuate central airway obstruction. This study demonstrates that both Direct Laryngoscopy with Rigid Bronchoscopy and Fluoroscopic delivery of Tracheal stents are equally effective and limitations in both methods (secondary to stenosis site or resource access) will be overcome by proficiency in both techniques.

**REFERENCES**


