SELF-EXPANDABLE METALLIC TRACHEOBRONCHIAL STENT INSERTION AND ENDOBRONCHIAL ELECTROCAUTERY WITH FLEXIBLE BRONCHOSCOPY: PRELIMINARY RESULTS AT A CANCER CENTER

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Background and Purpose: Technical developments have facilitated the implantation of metallic stents and the use of endobronchial electrocautery through a flexible bronchoscope to reestablish airway patency in patients with airway obstruction. Their application in a 180-bed cancer center is described.

Patients and Methods: From August 2000 to December 2001, 12 patients (2 women, 10 men, mean age 53.3 yr) were treated by insertion of a self-expandable metallic tracheobronchial stent (SEMS). Malignant airway obstruction was the indication for the procedure in nine patients, two of whom underwent preliminary debulking using SEMS with or without electrocautery. Severe benign subglottic or tracheal stenosis was the indication for the procedure in two patients. The remaining patient with esophageal cancer received a double bronchial and esophageal SEMS due to involvement of a non-obstructing bronchoesophageal fistula.

Results: Symptomatic improvement was seen in all 12 patients. Removal was performed in one patient. Five patients died during follow-up with a median survival of 44 days, attributed to the advanced stage of recurrent disease. The median follow-up for the six surviving patients was 23 weeks. No major short-term complications of the procedure were found.

Conclusions: SEMS is a promising technique for the management of airway obstruction. The stent is selected according to the specific clinical situation. Metallic and silicone stents are complementary. SEMS should not be used in patients who require only temporary relief of tracheobronchial obstruction.

Obstruction of the trachea or main bronchi is commonly caused by malignant airway disease, either by extrinsic compression from the tumor or mediastinal lymphadenopathy, or by an exophytic intraluminal process. Benign stenoses usually result from intubation injury but can also be caused by many inflammatory processes and systemic diseases with tracheobronchial involvement. Airway strictures present a substantial challenge to the bronchoscopist and patients often present as emergencies with dyspnea and stridor. Recently, pulmonologists and manufacturers have become increasingly interested in expanding the application of airway stent insertion [1, 2]. In 1990, Dumon et al published the results of experience with a new dedicated tracheobronchial prosthesis made of molded silicone [3, 4]. Since then, the Dumon silicone stent (Novatech, Aubagne, France) has been widely used for both malignant and benign airway diseases and is considered the best [5]. In contrast, metallic stents have been more or less abandoned due to significant complications following their placement [6]. The high pressures exerted by the Gianturco stent (Cook Inc., Bloomington, IN, USA) over the airway mucosa may lead to mucosal ischemia and possible penetration into...
the mediastinum. Once deployed, the Palmaz stent (Johnson & Johnson Interventional Systems Co., Warren, NJ, USA) can be recompressed by external forces such as vigorous coughing, and this plasticity prevents it from expanding, thereby partially obstructing the lumen of the airway. Studies of stent insertion without prior airway dilatation, or using only a flexible bronchoscope and fluoroscopic guidance, led to attempts to merge the qualities of both metallic and silicone stents. Second-generation self-expandable metallic stents (SEMS) — the Wallstent (Schneider Scientific, Natick, MA, USA) — constructed with metal alloys with or without a thin biocompatible membrane have now become available.

Electrocautery is another alternative modality for endobronchial therapy. Although it is widely used in surgery and in endoscopic procedures in gastroenterology and urology, its use in the tracheobronchial tree has been limited. Technical developments have facilitated the application of endobronchial electrocautery using a flexible bronchoscope under topical anesthesia. The technique is a straightforward, safe, and quick method to restore airway patency [7].

Here, we describe our initial experience of SEMS insertion and endobronchial electrocautery employing a flexible bronchoscope.

Materials and Methods

Our team included a pulmonologist, chest surgeon, otolaryngologist, and interventional radiologist. Patients suspected of having a large airway obstruction underwent flexible bronchoscopy to confirm the diagnosis and assess the need for stent placement or endobronchial electrocautery. The length of the obstructed segment was measured by withdrawing the tip of the flexible bronchoscope from its distal to proximal end. An estimate of the length as well as the diameter of the corresponding normal airway was also obtained from the images of helical computerized tomography (CT) scan with multiplanar reconstruction (helical CT/MPR). Spirometric data were obtained as dictated by clinical need rather than at regular intervals. Periodic clinic visits were maintained to confirm continued improvement and early detection of complications.

Results

From August 2000 to December 2001, 12 patients were treated by insertion of a SEMS (Table). There were two women and 10 men with a mean age of 53.3 years (range, 33–79 yr). The underlying malignancies included tongue cancer (4 patients), esophageal cancer (3), metastatic neck cancer (2), parapharyngeal cancer (1), leukemia (1), and recurrent lung cancer (1). Nine stents were implanted in the trachea, two in the left main bronchus (LMB), and one across the trachea and LMB. Malignant airway obstruction or extrinsic compression was the indication for SEMS placement in nine patients, of whom two underwent preliminary debulking using SEMS with or without electrocautery before concurrent chemoradiotherapy (CCRT) (Fig. 1). The other seven had recurrent diseases. In three patients with recurrent tongue cancer, we used intro-susception combining SEMS and a trimmed endotracheal tube or tracheostomy to bypass the long tracheal stenosis or seal the fistula (Fig. 2). One patient each underwent treatment for severe subglottic stenosis and tracheal stenosis following intubation and tracheostomy (Fig. 3). The length of stenosis, its proximity to the vocal cord, and fibrosis secondary to radiotherapy
Table. Patient characteristics and follow-up after stent placement

<table>
<thead>
<tr>
<th>Age/Sex</th>
<th>Diagnosis</th>
<th>Indication</th>
<th>Location</th>
<th>Dyspnea grade (before)</th>
<th>Dyspnea grade (Day 14)</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>79/F</td>
<td>Esophageal cancer</td>
<td>MAO</td>
<td>TR</td>
<td>IV</td>
<td>I</td>
<td>Died on day 50</td>
</tr>
<tr>
<td>69/F</td>
<td>Leukemia</td>
<td>BS</td>
<td>TR</td>
<td>IV</td>
<td>I</td>
<td>Removed on day 28</td>
</tr>
<tr>
<td>55/M</td>
<td>Tongue cancer</td>
<td>MAO</td>
<td>TR</td>
<td>IV</td>
<td>I</td>
<td>Died on day 44</td>
</tr>
<tr>
<td>60/M</td>
<td>Esophageal cancer</td>
<td>BEF</td>
<td>LMB</td>
<td>III</td>
<td>0</td>
<td>38 wk</td>
</tr>
<tr>
<td>46/M</td>
<td>Metastatic neck cancer</td>
<td>MAO*†</td>
<td>TR</td>
<td>III</td>
<td>0</td>
<td>25 wk</td>
</tr>
<tr>
<td>45/M</td>
<td>Tongue cancer</td>
<td>BS</td>
<td>TR</td>
<td>III</td>
<td>0</td>
<td>24 wk</td>
</tr>
<tr>
<td>60/M</td>
<td>Metastatic neck cancer</td>
<td>MAO*</td>
<td>TR</td>
<td>IV</td>
<td>1</td>
<td>Died on day 91</td>
</tr>
<tr>
<td>33/M</td>
<td>Parapharyngeal cancer</td>
<td>MAO</td>
<td>LMB</td>
<td>III</td>
<td>0</td>
<td>22 wk</td>
</tr>
<tr>
<td>51/M</td>
<td>Esophageal cancer</td>
<td>MAO†</td>
<td>TR</td>
<td>IV</td>
<td>1</td>
<td>Died on day 40</td>
</tr>
<tr>
<td>43/M</td>
<td>Tongue cancer</td>
<td>MAO</td>
<td>TR</td>
<td>IV</td>
<td>1</td>
<td>Died on day 35</td>
</tr>
<tr>
<td>41/M</td>
<td>Tongue cancer</td>
<td>MAO†</td>
<td>TR</td>
<td>IV</td>
<td>0</td>
<td>13 wk</td>
</tr>
<tr>
<td>58/M</td>
<td>Lung cancer</td>
<td>MAO†</td>
<td>TR+LMB</td>
<td>IV</td>
<td>0</td>
<td>9 wk</td>
</tr>
</tbody>
</table>

F = female; MAO = malignant airway obstruction; TR = trachea; BS = benign stenosis; M = Male; BEF = bronchoesophageal fistula; LMB = left main bronchus. *Preliminary debulking; †electrocautery before stenting.

Prohibited surgery or silicone stent placement in these patients. The remaining patient, who had esophageal cancer, underwent double bronchial and esophageal SEMS due to involvement of a non-obstructing bronchoesophageal fistula, before undergoing CCRT (Fig. 4).

Symptomatic improvement was noted in all 12 patients. In 11 of the patients with airway obstruction, the dyspnea index improved significantly after implantation (before vs. day 14) (Table). Because of imminent respiratory failure or use of a tracheostomy, pulmonary function tests could be compared in only six patients. An increase in the forced expiratory volume in one second (FEV1; mean, 696.7 mL; range, 470–1,140 mL; p < 0.01) was observed in all patients. However, the SEMS was removed in one patient 4 weeks after its insertion due to the relapse of leukemia involving mediastinal lymph nodes (LN) with recurrent bilateral vocal cord paralysis and severe mucosal swelling over the lower trachea and bilateral main bronchi. Emergency tracheostomy relieved this patient’s dyspnea. The SEMS was removed simultaneously without difficulty before neoepithelialization. A T-tube was later placed both for preservation of phonation and preven-

Fig. 1. Severe mixed (intraluminal & extraluminal) tracheal obstruction in a 46-year-old male patient with right neck metastatic carcinoma. The self-expandable metallic stent (SEMS; arrow) was inserted before concurrent chemoradiotherapy (CCRT). After relief of dyspnea was achieved, the enlarged left hilar lymph node shown on computed tomography scan was sampled using transbronchial needle aspiration.
Fig. 2. A patient with recurrent tongue cancer and tracheal invasion: the self-expandable metallic stent (SEMS; arrow) was inserted first to relieve a severe obstructing fistula. Progressive disease resulted in severe supraglottic edema and imminent bilateral vocal cord paralysis, which made tracheostomy inevitable.

Fig. 3. Left: A) Severe hour-glass type subglottic stenosis following endotracheal intubation. B) Tracheal stenosis following tracheostomy. Supraglottic edema was also present. Right: improved airway mechanics and reduced air trapping in the latter patient after implantation of a self-expandable metallic stent (SEMS).
Self-expandable Metallic Tracheobronchial Stent

establish airway patency, rapid progression of the tumor with involvement of the carina and encroachment of bilateral main bronchi occurred. Fistula at the take-off of the LMB was also found. Placement of a SEMS was not feasible under these circumstances. The Dumon-Novatech Y-shaped silicone stent was not available at that time, and he died of multiple organ failure following jejunostomy dysfunction with hemoperitoneum and aspiration pneumonitis. A 61-year-old male patient with recurrent esophageal cancer and serial laryngotracheal stenosis had severe supraglottic edema, right vocal cord paralysis, and external compression of the posterior tracheal wall 6 cm in length with patency less than 50%. Tracheostomy was performed directly to circumvent the obstacle instead of placing a SEMS.

Discussion

Similar to previous studies, we have demonstrated that placement of a SEMS in inoperable malignant airway stenosis relieved dyspnea, contributing to improved quality of life with minimal complications [8–11]. Good palliation increases meaningful survival. In certain complicated situations, including diffuse stenosis, long stenosis, and bilateral bronchial stenoses, implantation of combination stents of several types including SEMS and silicone stents has become a standard procedure. We successfully applied the method of introsusception combining SEMS and a trimmed endotracheal tube or tracheostomy in three patients with recurrent tongue cancer with tracheal invasion and fistula formation.

In two patients, the airway obstruction was removed using SEMS with or without electrocautery before CCRT. This strategy has several advantages. Reduction of dyspnea and post-obstructive pneumonia risk may enhance tolerance to treatment and reduce the risk of sepsis during the neutropenic phase of treatment. It decreases the incidence of radiation pneumonitis. By creating well-delineated borders, it enables more accurate irradiation and facilitates assessment of response to treatment. Although there have been no randomized studies of such combined therapeutic modalities, improvement in survival was reported in two studies using laser or cryotherapy as preliminary debulking treatment followed by external irradiation in patients with obstructive lung cancer [12, 13]. Combined therapy using stents and external irradiation has also been reported. Radiotherapy prevented local recurrence after stent placement [14]. The so-called GASBI protocol trial is now under way in France to compare the survival, treatment tolerance, and quality of life between two randomized arms with or without preliminary debulking in patients with unresectable stage III non-small-cell lung cancer and stenosis of a major bronchus of more than 50% [15].

Despite its satisfactory result for malignant obstruction, the use of SEMS remains limited under certain circumstances. For malignant disorders involv-

ing the carina, SEMS is not adequate due to its straight design. Hsu et al demonstrated a method using two overlapping uncovered Wallstents to bypass the obstruction [16]. However, rapid tumor ingrowth through the porosity often endangers the airway again. Dumon-Novatech Y-stents are of value in such situations [17], but their placement requires more technical experience and greater consideration of the degree of tracheobronchial deviation and stenosis than does the placement of straight stents [18].

Serial laryngotracheal stenoses often occur in patients with head and neck cancer or esophageal cancer, either pre-treatment or recurrent. Wassermann et al proposed a combined approach using SEMS plus unilateral cordectomy to restore airway continuity and ensure voice preservation for patients with tracheal stenoses and bilateral vocal cord paralysis [19]. However, frequent coexistent severe supraglottic edema further complicates the use of this technique. Simple insertion of SEMS cannot be performed in these patients and only one patient in our study received this procedure due to concomitant fistula, to reduce the risk of mediastinitis.

Although findings from several studies support SEMS placement for benign tracheobronchial stenosis, reported studies have had inadequate follow-up of long-term complications, as well as difficult removal and material fatigue [20–22]. Early referral to an otolaryngologist or thoracic surgeon appears to be needed especially when there are features that suggest a poor outcome is likely with endoscopic therapy. Circumferential scarring with cicatrical contracture, scarring longer than 1 cm in vertical dimensions, and tracheomalacia are unfavorable presentations. Considering the delayed healing and frequent wound infection secondary to antecedent radiotherapy, our patient with benign tracheal stenosis did not undergo segmental resection and end-to-end anastomosis. In nonoperable patients and in those who decline surgery, placement of a silicone stent as the next line of therapy is suggested if there is access to physicians with the ability to perform rigid bronchoscopy. SEMS placement appears to be indicated if the patient has failed silicone stent placement or develops recurrent obstruction secondary to secretions or granulation tissue. Compared with its risk in patients with malignant stenosis, silicone stent displacement carries a higher risk in patients with benign airway stenosis since structural support is missing. Stents placed within 2 cm of vocal cords are particularly prone to migrate. For this reason, we inserted a SEMS in the patient with subglottic stenosis. Recently, Vergnon et al designed a new silicone stent with narrow central and larger distal parts to decrease the migration rate [23]. This new stent combines the excellent stability of the SEMS and the tolerance and easy removal of straight silicone stents. It also allows prolonged use.

The ability to effectively seal a malignant tracheobronchial fistula without creating a concomitant obstructive component by a tightly fitting stent is another welcome use of SEMS. Surgical closure by thoracotomy is often not feasible in these patients, who usually have advanced disease and thus a short life expectancy. Double tracheobronchial and esophageal stenting is often required to treat the concomitant esophageal narrowing, as in our patient.

The SEMS has the potential to elongate when loaded on the introducer in a constrained manner. Partial distal deployment of the covered version with an inappropriately large diameter may endanger the main bronchus, especially when the stenosis approaches the distal end of the trachea. The choice of SEMS with adequate diameter and length poses a challenge to physicians. Helical CT/MPR is a superior modality to perform estimations for this selection. Deployment should be quick and very accurate, and the shortening of SEMS requires experience.

Electrocautery was applied in five of our patients with endobronchial exophytic lesions. All these procedures resulted in successful palliation and four were followed by insertion of SEMS. Electrocautery seems to be an efficacious technique, which is a cheaper alternative to laser treatment. It can remove a lesion rapidly. In contrast with laser treatment, it has the advantage of greater peripheral approachability. Use of this technique will increase when an earthed, insulated flexible bronchoscope and accessories become commercially available.

In conclusion, among the second-generation SEMS, Ultraflex currently holds promise as a useful prosthesis for the management of benign and malignant airway lesions. However, the published experience with the Ultraflex is quite limited, and long-term complication rates have not been determined. Metallic and silicone stents are complementary in the management of tracheobronchial airway obstruction. Stenting should be based on the patient’s particular condition, and not on whether the operator has expertise with only one type of stent or bronchoscopic procedure. Silicone stents must be inserted through a rigid bronchoscope, whereas SEMS can be inserted using a flexible bronchoscope depending on the cardiopulmonary status of the patient. Skilful handling of a rigid bronchoscope is mandatory. Lack of training precludes the use of other treatment methods by the pulmonologist and can lead to an erroneous interpretation of what is the easiest stent to place or the best to treat a given condition. Operators must resist pressure from manufacturers who overemphasize the merits of their products. SEMS should not be used in patients considered to have only temporary

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need for relief of tracheobronchial obstruction. It is probably unsuitable in the presence of carinal involvement, combined laryngotracheal stenoses, and benign airway stenosis with features predictive of poor outcome. In addition to subjective improvement, prospective studies are needed to test the efficacy of stents with objective parameters, such as serial flow-volume loops, allowing comparison between different circumstances.

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References