Self-expanding Stents in the Treatment of Tracheobronchial Obstruction*

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The self-expandable stainless steel stents (Gianturco, William Cook, Bjaeverskov, Denmark) used extensively in biliary ducts and the vascular system have recently been modified for use in the tracheobronchial tree. Between March 1991 and September 1992, six patients with unresectable tracheobronchial and mediastinal diseases were treated with the placement of one or more self-expanding stents under direct vision with a fiberoptic bronchoscope. All patients had been intubated for severe respiratory insufficiency. In all cases, immediate relief of respiratory symptoms was achieved and all patients were extubated 1 or 2 days after stent placement. Tolerance of the stents was excellent. No patient complained of pain, discomfort, or foreign body sensation. No infection or obstruction of the stents was observed. The chest roentgenogram and the bronchoscopies performed during follow-up have shown no change in the position of the stents. Our results seem promising since these devices provide effective palliation of airway obstructions and are well tolerated.

(Chest 1994; 106:86-90)

Key words: tracheobronchial obstruction, self-expandable stainless steel stents, tracheobronchial strictures

Malacia, extrinsic compressions, and fibrotic structures of trachea and main bronchi may be treated conservatively by means of airway prostheses. Those currently used in clinical practice are stoma prostheses (Montgomery T tubes and Westaby T-Y tubes) and endoprostheses introduced into the airways endoscopically. Silicone endoprostheses, both straight and Y tubes, have proven effective in the treatment of selected tracheobronchial obstructions; however, they present the disadvantage of interfering with mucociliary function, thus hindering the clearance of bronchial secretion, and are potentially life-threatening due to the risk of displacement. To overcome these disadvantages, the self-expanding stainless steel stents (Gianturco, Cook) used extensively in biliary ducts and the vascular system have recently been modified for use in the tracheobronchial tree. Preliminary clinical results reported in the literature seem promising. Gianturco stents provide effective palliation of airway obstruction, are well tolerated, stable, and allow normal clearance of secretions.

We describe our initial experience with the use of self-expanding stents for treatment of tracheobronchial and mediastinal diseases with obstruction of the airway.

**MATERIALS AND METHODS**

The self-expanding stent (Gianturco) is a cylindrical structure made of stainless steel wire bent in a zigzag pattern intended to be used for producing and maintaining patency of stenosed trachea or main bronchi. Various diameters (15, 20, and 30 mm) and lengths (25-mm single stent, 50-mm double stent) are available. The stent has short lateral hooks, which become embedded in the tracheobronchial mucosa, preventing displacement.

The stent is inserted in its compressed form into an introducer sheath by means of a metallic pusher. A stent positioner is used to advance the prosthesis to the farthest end of the sheath. It is then extruded into the airway by holding the stent positioner steady while the introducer sheath is withdrawn carefully. As the prosthesis is released from the introducer sheath, it will tend to expand to its original diameter. Since the diameter of the stent is always oversized in relation to that of the airway, the residual elastic radial force in the stent will keep the airway patent. Airway dilation continues until a balance is reached between the elastic resistance of the tracheobronchial wall and the expanding force of the prosthesis.

Before stent placement, a careful endoscopic assessment of the upper airways is carried out to verify the site and extent of the lesion. The stent is inserted when the patient is under general anesthesia under endoscopic or under fluoroscopic control.

Between March 1991 and September 1992, six patients with unresectable tracheobronchial and mediastinal diseases were treated with the placement of one or more self-expanding stents. All the patients had an endotracheal ventilating tube (five through a tracheostomy and one through the mouth) because of severe respiratory insufficiency, and they were receiving mechanical ventilation. Stent placement was performed under direct vision with a fiberoptic bronchoscope. In patient 1, fluoroscopy was also used to monitor placement. In all cases, the bronchoscope was introduced into the airway through the endotracheal tube, while the introducer sheath and the stent positioner were passed parallel to it.

Clinical data of the six patients are summarized in Table 1. Patient 1 had undergone a left single-lung transplant for pulmonary emphysema and had pre-anastomotic kinking of the left main bronchus, 2 cm distal to the main carina, 1 cm proximal to the anastomosis, and 2 cm proximal to the take-off of the left upper-lobe bronchus. Reduction of the left-main bronchus lumen was more than 70 percent. Patients 2, 3, 5, and 6 had segmental tracheomalacia diagnosed by tracheoscopy. In patient 2, the tra-
Table 1—Clinical Data of Six Patients Treated With Gianturco Stents

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Age, yr</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>49</td>
<td>Kinking of the recipient bronchus proximal to the anastomosis in patient with a left single-lung transplant</td>
</tr>
<tr>
<td>2</td>
<td>75</td>
<td>Segmental tracheomalacia in patient with COPD</td>
</tr>
<tr>
<td>3</td>
<td>78</td>
<td>Segmental tracheomalacia in patient with COPD</td>
</tr>
<tr>
<td>4</td>
<td>36</td>
<td>Extrinsic compression of patient's trachea by thymic carcinoma</td>
</tr>
<tr>
<td>5</td>
<td>79</td>
<td>Segmental tracheomalacia in patient with COPD</td>
</tr>
<tr>
<td>6</td>
<td>70</td>
<td>Segmental tracheomalacia in patient with COPD</td>
</tr>
</tbody>
</table>

The carina collapsed on expiration, with complete obstruction of the lumen from 4 cm below the vocal cords to 3 cm from the main carina, a stretch of 4 cm. In patient 3, the portion of the trachea that collapsed on expiration determined a subtotal obstruction of the lumen and extended over a 4- to 5-cm segment, which ended 2 cm above the main carina. Although the malacic segment was of the same length in patient 5, the lesion determined the complete obstruction of the lumen on expiration and ended 3 cm above the main carina. In patient 6, the collapsing portion of the trachea, with subtotal obstruction of the lumen during expiration, was longer (6 to 7 cm) and ended 2 cm above the main carina.

Patient 4 had airway compression due to an unresectable thymic carcinoma. Bronchoscopy performed with a pediatric fiberoptic bronchoscope (Olympus BF-3C20, external diameter 3.5 mm) showed the distal trachea and right main bronchus to be reduced to a caliber of 7 mm and 6 mm, respectively, without neoplastic invasion of the airway.

Stent placement was successful in all cases and the patients were able to breathe spontaneously immediately after the procedure. A total of eight prostheses (four single and four double) were inserted into the six patients. The stents were placed in the distal trachea of four patients, in the proximal trachea of one patient, and in the left-main bronchus of another patient.

RESULTS

The results are summarized in Table 2. All patients had immediate relief of respiratory symptoms and were extubated 1 or 2 days after placement of the stent. The patient with thymic carcinoma (patient 4) died 2 months after stent placement from neoplastic cachexia, while one patient with tracheomalacia (patient 5) died 3 months after stent placement from acute myocardial infarction; both died without respiratory symptoms. The other four patients are alive and well with a mean follow-up of 14 months (range 8 to 24 months). Tolerance of the stents was excellent. Two patients complained of a slight cough, which disappeared a couple of days after stent placement. No patient complained of pain, lasting discomfort, or foreign body sensation. There was no infection or obstruction of the stents. The chest roentgenogram and the bronchoscopies performed in follow-up have shown no change in the position of the stents. In the patient with a transplanted left lung (patient 1), a bronchoscopy performed 6 months after placement showed a small granuloma at the proximal end of the stent that was treated with topical injections of steroids. Successive bronchoscopies have shown no further granulomas at 24 months.

DISCUSSION

The self-expanding stents are an alternative to silicone prostheses in the conservative treatment of a number of tracheobronchial and mediastinal diseases with obstruction of the airway. Suitable candidates for the use of these stents are patients with acquired tracheomalacia from long-term endotracheal intubation, chronic external compression of the trachea after removal of benign mediastinal goiters and benign mediastinal tumors, and patients with relapsing polychondritis and tracheomalacia associated with COPD. These latter patients are ideal candidates for these stents since they are usually elderly and at high risk for surgery. Patients with extrinsic compression of the trachea or of the main bronchi by unresectable mediastinal tumors or mediastinal fibrosis due to radiotherapy or infection can also be treated with these stents. The use of self-expanding stents in patients with extrinsic compression and secondary invasion of the airway by tumor is also feasible as a palliative measure associated with preliminary laser coring of the intraluminal portion of the tumor. To prevent recurrence of intraluminal growth of the tumor in such cases, a modified stent with a nylon and polyvinyl chloride cover has been developed and used with good results.

Further applications for self-expanding stents are

Table 2—Summary of Results in Six Patients Treated With Gianturco Stents

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Stents Placed</th>
<th>Follow-up, Mo</th>
<th>Outcome</th>
<th>Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 single</td>
<td>24</td>
<td>Alive and well</td>
<td>Small granuloma at proximal end of the stent</td>
</tr>
<tr>
<td>2</td>
<td>1 double</td>
<td>12</td>
<td>Alive and well</td>
<td>None</td>
</tr>
<tr>
<td>3</td>
<td>1 double</td>
<td>11</td>
<td>Alive and well</td>
<td>None</td>
</tr>
<tr>
<td>4</td>
<td>3 single</td>
<td>2</td>
<td>Deceased with the stent in situ without respiratory symptoms</td>
<td>None</td>
</tr>
<tr>
<td>5</td>
<td>1 double</td>
<td>3</td>
<td>Deceased with the stent in situ without respiratory symptoms</td>
<td>None</td>
</tr>
<tr>
<td>6</td>
<td>1 double</td>
<td>8</td>
<td>Alive and well</td>
<td>None</td>
</tr>
</tbody>
</table>
anastomotic fibrotic strictures after a tracheobronchial resection or lung transplantation. They provide a satisfactory alternative to surgery, which has a high incidence of morbidity and mortality in such cases, particularly in patients with transplanted lungs. The advent of lung transplantation has, in fact, increased the number of potential candidates for the use of tracheobronchial stents since the airway anastomosis still constitutes a surgical weak point. A 14 percent bronchial complication rate is reported\textsuperscript{17} mainly from dehiscence, stenosis, or malacia of the anastomosis. Patient 1 of our series, who underwent single-lung transplantation for emphysema, received an undersized donor lung. This discrepancy determined kinking with partial torsion of the recipient bronchus proximal to the anastomosis with a consequently reduced lumen\textsuperscript{18} (Fig 1). The placement of a single stent at the obstruction straightened the airway (Fig 2) and enabled the patient to be extubated and to lead a normal life.

Our indications for the placement of self-expanding stents always derived from the need to treat respiratory insufficiency in intubated patients in whom the operation would have entailed high morbidity and mortality risks (patient 1), when an operation would not have been functionally tolerated (patients 2, 3, 5, and 6 with tracheomalacia associated with COPD), or when the extent of the tumor prevented a surgical resection (patient 4 with thymic carcinoma).

In all our cases, we could have used the more common silicone prostheses (T-tubes and straight endoprostheses), but we preferred the self-expanding stents because they have some significant advantages. These stents allow normal clearance of secretions, do not interfere with bronchial orifices, have stable positioning, and allow endotracheal intubation should...
the front section of double stents will fully expand and hook onto the airway mucosa while the back section is still inside the introducer sheath. This allows a more precise placement.

A third disadvantage is that this self-expanding stent (Gianturco) has no longitudinal elasticity unlike other self-expandable metallic stents that have recently become available on the market.\(^\text{10}\) This means that it tends to remain straight whatever the morphology of the tracheobronchial tree (Fig 4). This does not impede airway patency but extreme caution is required should intubation ever be necessary or during secretion suction within the tracheobronchial tree to avoid entrapment of tubes and catheters.

The experience reported in the literature regarding the use of self-expanding stents in the upper airways is still limited to a few patients.\(^\text{11-14}\) The stents provide effective palliation of airway obstructions and are well tolerated. Currently, only Nashef et al\(^\text{13}\) have reported any complications in their series of 15 patients: granuloma formation leading to stent removal in 3 patients with active fibroinflammatory stenosis, dysphagia in one, suction catheter entrapment in one, and fatal massive hemoptysis in another patient with segmental bronchial wall necrosis. This suggests that active fibroinflammatory stenosis and airway necrosis do not constitute an indication for the use of metal stents and may be more satisfactorily treated with silicone stents. On the other hand, self-expanding stents have proven safe and effective in the treatment of malacic and pure fibrotic stenosis.

In summary, our results seem promising. Self-expanding stents provide effective palliation of airway obstructions and are well tolerated by patients. Even though accurate placing cannot always be guaranteed, technical expertise and careful choice of stent length can obviate this difficulty. Nevertheless, the long-term mechanical resistance of self-expanding stents still remains to be verified, as do possible “foreign body” reactions.

**REFERENCES**


**FIGURE 4.** Segmental tracheomalacia in COPD. Chest roentgenogram. The stent, lacking longitudinal elasticity, lies across the tracheal lumen but guarantees airway patency.
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