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TRACHEOBRONCHIAL STENTING

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INTRODUCTION

Fluoroscopic placement of uncovered or covered self-expandable metallic stents is a relatively new method of treating malignant and benign tracheobronchial strictures. Although no large controlled trials have been performed, published data (Table. 1) suggest that the procedure is a safe and easy nonsurgical treatment in cases of inoperable tracheobronchial strictures with resultant dyspnea [1-8]. In addition, the procedure has been believed to reduce the considerable morbidity and complication rates associated with conventional silicone tube insertion[1)3)6)]. However, complications such as migration of the stent, fracture of the metallic mesh, blockage, tumor ingrowth, and formation of granulation tissue occurred in some cases during and after the procedure[1)2)6)9)]. Some of these complications, such as migration of the stent, fracture of the metallic mesh, and formation of granulation tissue, could be avoided with use of a retrievable covered stent as in esophageal strictures[10)].

Recently, an uncovered expandable metallic stent was used in the treatment of tracheobronchial strictures(n=8) or tracheobronchomalacia(n=8) of 16 infants and children[7)]. The stent was removed in six of eight cases with tracheobronchomalacia and in one of eight cases with tracheobronchial strictures 6 - 44 months after stent placement. All cases were reported to be well with no recurrence after removal of the stent. Removal of the stent, however, was difficult and needed general anesthesia because the stent design was not optimized for removal. Moreover, one patient died at attempted removal because the stent was tightly bound into the tracheal wall by an inflammatory reaction[7)].

MATERIALS AND METHODS

In order to make the stent removable and more tolerable, we designed a polyurethane-covered retrievable expandable nitinol stent and a device for removal of the stent. Under fluoroscopic guidance, the stent was placed in 45 consecutive patients with dyspnea and cough. Twenty-five patients had a malignant stricture and 20 patients a benign stricture. The underlying malignancies were recurrent carcinoma of the lung or trachea after surgery in six patients, inoperable lung cancer in eight patients, inoperable esophageal cancer in six patients, and extrinsic compression due to metastases in five. Seven of the 25 patients had esophagorespiratory fistulas. The causes of benign strictures were

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endotracheal or bronchial tuberculosis in 10 patients, tracheostomy in six patients, intubation in three patients, and tracheobronchomalacia in one patient. The site of stricture was at the trachea in 26 patients, at the left main bronchus in 11, at the right main bronchus in three, at the lower trachea straddling the left main bronchus in four, and at the lower trachea straddling the right main bronchus in one.

The stent was woven 16 times from a single thread of 0.2-mm nitinol wire filament in a tubular configuration. To prevent tumor growth or mucosal hyperplasia through the stent wires, the stent was covered by a dipping method using 12% polyurethane solution. The tracheal stent was 16 or 20 mm in diameter when fully expanded and 40 to 90mm long, and the bronchial stent was 10 or 12 mm in diameter and 30 to 50mm long. To make the stent removable, a drawstring made from nylon monofilament was attached to the upper inner margin of the stent. A nylon loop(2 mm in diameter) was hooked inside to each bend of the proximal end of the stent and secured with suture (Fig. 1). Another nylon thread was passed through each of the nylon loops to form a larger loop (a drawstring) that filled the circumference of the inside of the stent. The resulting loop was tied up. The stent was constructed by us in our research laboratory. A stent, at least 10 mm longer than the stricture, was selected for placement so that the proximal and distal parts of the stent would rest on the upper and lower margins of the stricture, respectively. As for the diameter of the tracheal stent, a 20-mm stent was selected for the male patients, and a 16-mm stent for the female patients. As for the diameter of the bronchial stent, a 12-mm stent was selected for the male patients and a 10-mm stent for the female patients.

A tracheal stent introducer set(Fig. 2) consists of an 8-mm sheath, a 4-mm breathing tube, a pusher catheter, and a guiding balloon catheter 8 mm in diameter and 3 cm long. A deflated balloon catheter was passed through a breathing tube, and then both were passed through a pusher catheter. These three

Table 1. Results of Conventional Expandable Metallic Stents

	Rousseau(1)	Sawada(2)	Tsang*	Song**
No. of patients	55	14	12	39
Types of stents	G,W	G	W	G,S
Technical success (%)	96	100	100	95
Clinical success (%)	100	86	92	91
Mean follow-up (mo)	10	5	10	19
Recurrence rate (%)	16	14	25	54

Note G = Gianturco stent, W = Wallstent, S = Strecker stent,
* Eur J Cardio-thorac Surg 1992;6:555-560
** Radiology 2000;217(p):654

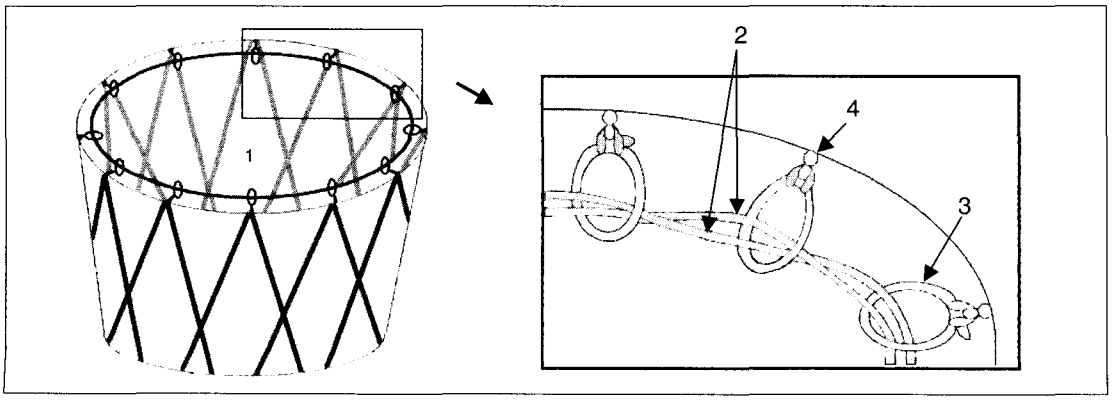

Fig 1. Diagrams show two drawstringsattached to the upper inner margin of the stent. 1 = central lumen, 2 = drawstrings, 3 = nylon loop, 4 = upper margin of the wire

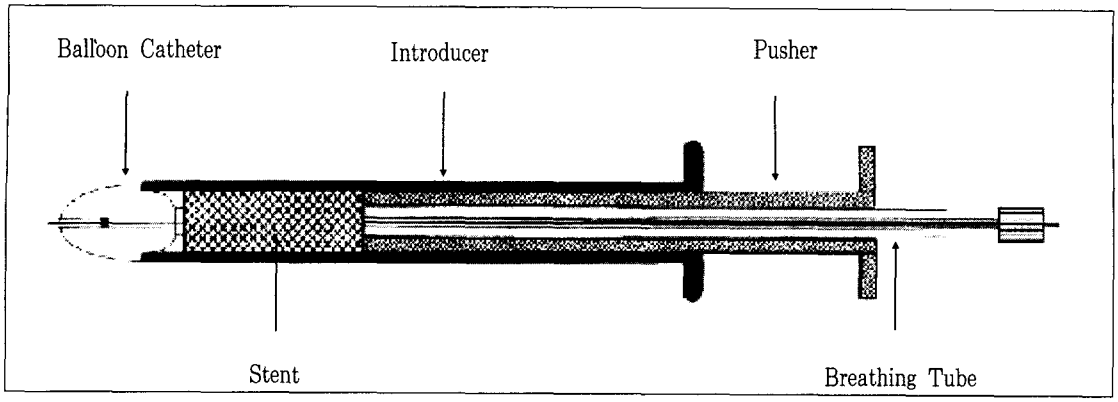

Fig 2. A diagram of a tracheal stent introducer set

were pushed into the sheath, with half of the balloon lying out of the sheath. From the opposite end, a stent was passed over the balloon catheter and breathing tube and then compressed to be loaded between the breathing tube and the distal end of the sheath. A stent retrieval set consists of a 13-F sheath, a 10-F dilator, a hook wire, and a 0.035-inch guide wire. The end of the hook wire was constructed in a question-mark configuration to hook the drawstring of the stent. The distal 20-mm section of the question-mark portion was positioned at an angle of about 30 degrees to the axis. An additional bend was made in this section with the use of pliers so that the hook would not catch the end of the sheath when the hook was being withdrawn. A bronchial introducer set consists of a 14-F sheath, a dilator, and a pusher catheter.

The site, severity, and length of the stricture were evaluated before stent placement by means of plain radiography, computed tomography, bronchoscopy, and respiratory function studies (spirometry and arterial blood gas analysis). Topical anesthesia of the pharynx and larynx was routinely achieved with an aerosol spray before the procedure. Prophylactic antibiotics and steroids were not used. Drugs for sedation were routinely used. A 0.035-inch exchange guide wire was inserted through the mouth across the stricture into the distal portion of the trachea or bronchus under bronchoscopic guidance. A straight 5-F graduated sizing catheter was passed over the guide wire to the distal part of the stricture to measure the length of the stricture. The location of the narrowed tracheobronchial lumen was marked on the patient's skin under fluoroscopic control. In patients whose stricture was not well defined on the fluoroscopy, the guide wire was removed from the catheter and a small amount of diluted nonionic contrast medium was injected through the catheter to opacify the narrowed lumen and then the length of the stricture was measured. An angioplasty balloon catheter(3 to 4 cm long and 10 mm in diameter) was passed over the guide wire to a position astride the stricture. The balloon was slowly inflated with a diluted water-soluble contrast medium until the "hourglass deformity" created by the stricture disappeared from the balloon contour. The 0.035-inch exchange guide wire was changed to a super stiff J tip guide wire and the balloon was removed with the guide wire left in the trachea.

Under fluoroscopic guidance and with the patient in the right anterior oblique or supine position and in extension of the neck, the whole introducer set loaded with a stent, whose proximal part was lubricated with a water soluble lubricant, was passed over the guide wire into the trachea and was advanced until the distal tip of thecompressed stent reached approximately 1 cm beyond the stricture. And then, the guiding balloon catheter was deflated.

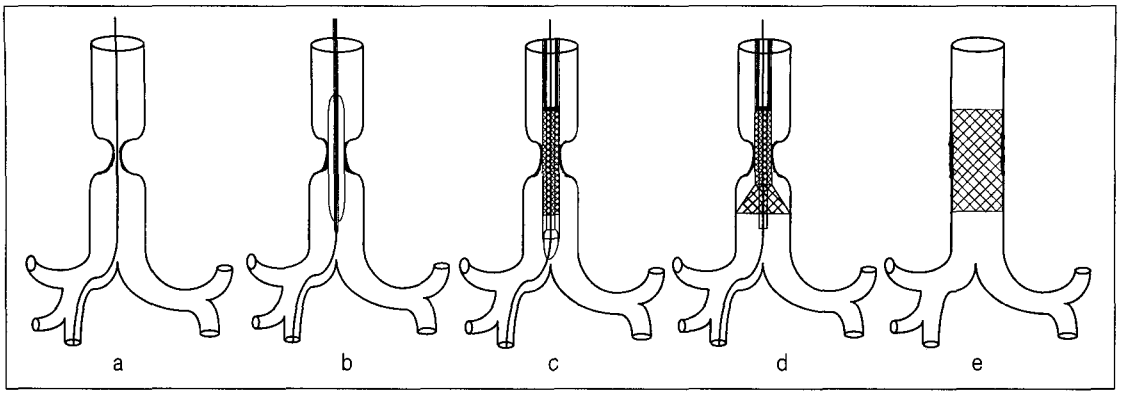

Fig 3. a-e. Diagrams show the technical steps in tracheal stent placement: insertion of a guide wire into the bronchus(a), dilation of thestricture with use of a balloon catheter(b), passing an introducer set through the stricture(c), withdrawing the sheath over the pusher catheter(d), and expansion of the stent in the trachea (e)

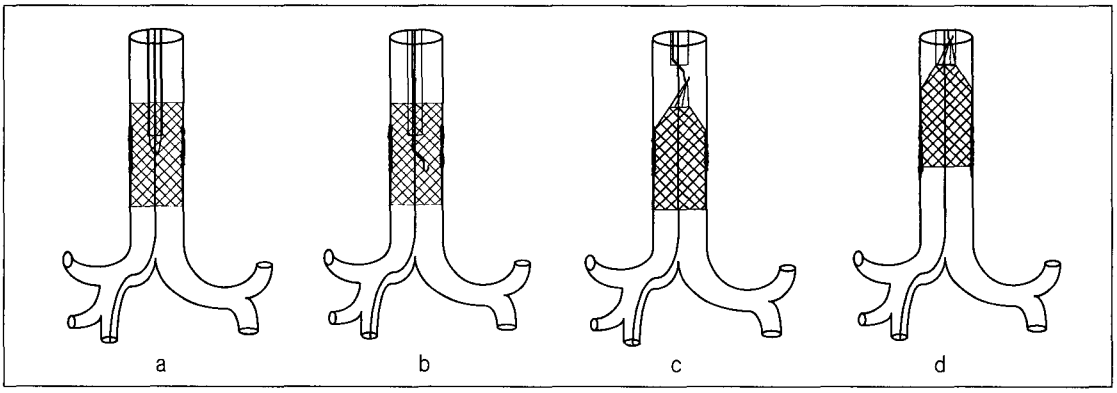

Fig 4. a-d. Diagrams show the technical steps in removal of the stent: insertion of a sheath with a dilator (a), insertion of a hook wire into the sheath(b), grasping the drawstrings by the hook wire(c), and withdrawing the hook wire through the sheath(d)

and the balloon catheter and the guide wire were removed. After that, the pusher catheter was held in place with one hand while the sheath was slowly withdrawn in a continuous motion with the other hand(Fig. 3). This freed the stent and allowed it to lie within the stricture and expand. Just after removal of the sheath, the pusher catheter, and the breathing tube, plain radiography was performed to verify the position of the stent. In the patient with an endotracheal tube for the tracheobronchial malacia, balloon dilation was not needed before stent placement and stent placement was performed through the endotracheal tube using the coaxial sheath technique.

We removed the stent from the patients with a benign or malignant stricture when complications such as severe pain or migration occurred. In patients with a benign stricture who had no complications, we electively removed the stent 8 weeks after placement. After topical anesthesia of the larynx, a 0.035-inch Terumo guide wire was introduced through the mouth and then across the stent into the distal trachea or bronchus. A sheath with a dilator was passed down over the guide wire into the proximal stent lumen. After the dilator was removed from the sheath, a hook wire was introduced into the sheath and was advanced until the hook was passed through the sheath into the stent lumen. And then the sheath with the hook was pulled out of the stent so that the hook hooked

onto the drawstring(Fig. 4). When this happened, the hook wire was withdrawn through the sheath to collapse the proximal stent when it reached the sheath tip. The sheath, the hook wire and the stent were then pulled out of the trachea.

RESULTS

Stent placement was technically successful and well tolerated in all but three patients. In three patients, the stent was misplaced but relocated successfully. After stent placement, all patients showed improvement of dyspnea. A striking improvement of aspiration symptoms occurred in six of seven patients with esophagorespiratory fistulas. In patients with a malignant stricture, no one showed stent migration after placement and stent removal was not needed in any patients. All patients with a malignant stricture died 1-29 weeks(mean, 9 weeks) after stent placement due to hemoptysis or progression of the underlying cancer. As for the complications in 20 patients with a benign stricture, stent migration occurred in eight patients. Five of the eight patients with stent migration underwent a second stent placement, while three patients with a subglottic stenosis underwent T-cannulation or tracheal resection because of frequent stent migration. The stent was electively removed from the first eight patients with a benign stricture 2 months after placement. The initial improvement rate in the eight patients was 100%, but only two patients maintained the initial improvement during the mean follow-up of 25 months(range, 19-31months) and did not need further treatment. After this, the stent was electively removed from seven patients 6 months after placement. Six of the seven patients maintained the initial improvement during the mean follow-up of 11 months(range, 3-24 months) and did not need further treatment.

COMMENTS

The polyurethane-covered retrievable expandable nitinol stent has several advantages over the conventional uncovered expandable metallic stent. There is little chance of tumor ingrowth in patients with a malignant stricture because the stent is covered by polyurethane membrane. Fracture of the stent is unlikely because the stent was woven from a single thread of nitinol wire. The stent can be easily relocated when misplaced. The stent also can be easily removed when it causes complications. Stent placement by use of a retrievable stent can extend the indications to patients with a benign stricture whose lesions were previously considered very difficult to treat, if not untreatable. The covered stent, however, does have important limitations. The insertion of a covered stent within the distal bronchial tree may occlude an orifice to an upper lobe, whereas placement at the level of the main carina may lead to obstruction of a main bronchus.

CONCLUSION

Use of covered retrievable expandable nitinol stents seems to be a feasible and useful effective method of treatment for patients with a malignant tracheobronchial stricture as well as for selected patients with a benign tracheobronchial stricture.

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