Original Article

J Chin Med Assoc
2004;67:458-464

Management of Malignant Tracheobronchial Stenoses with the Use of Airway Stents

Jang-Ming Su[1]
Tzu-Chin Wu[2]
Ming-Fang Wu[3]
Han Chang[4]
Ming-Chih Chou[1,5]

[1] *Division of Thoracic Surgery, Department of Surgery,*
[2] *Division of Chest Medicine,*
[3] *Division of Medical Oncology, Department of Internal Medicine,*
[4] *Department of Pathology, Chung-Shan Medical University Hospital, Taichung and*
[5] *Institute of Medicine, Chung-Shan Medical University, Taichung, Taiwan, R.O.C.*

Key Words
airway obstruction;
bronchoscopes;
neoplasms;
stents

Background. Tracheobronchial stenoses caused by malignant etiologies are life-threatening with respiratory distress symptoms. Airway stent insertion is an effective method of relieving the airway obstruction. We report our experience with the use of Dumon silicone stents and self-expandable metallic Ultraflex stents.

Methods. From July 1999 to December 2003, ten patients (7 men, 3 women) with a mean age of 56.3 years (range, 37 to 77 years) had stent insertion to manage their malignant airway stenoses. Underlying malignancies included 6 esophageal cancers, one NPC with mediastinal recurrence, 1 recurrent adenoid cystic carcinoma, 1 metastatic mediastinal lymphadenopathy and 1 mediastinal multiple myeloma. All patients had severe respiratory distress. All stents were placed through a rigid Efer-Dumon bronchoscope under general anesthesia.

Results. Eight Dumon silicone stents (4 tracheal, 1 bronchial and 3 Y-shaped) were placed in 7 patients. Four metallic Ultraflex stents (2 tracheal and 2 bronchial) were placed in 3 patients. There was no death related to stent placement, and there were no immediate complications after stenting. Significant improvement of respiratory distress was seen in 9 patients (90%) after stenting. Three stent migrations occurred in 12 stent placements. During follow-up to the present time, 7 patients died of disease progression, with a median survival of 5.2 months (range, 1 to 17.8 months) after stenting. Two patients remain alive, with survivals of 49 and 12 months respectively.

Conclusions. The insertion of the airway stents, either Dumon silicone stents or metallic Ultraflex stents, can provide an effective method to immediately relieve respiratory distress, to improve the quality of life and to prolong survival in patients with malignant central airway stenoses.

Malignant tracheobronchial stenosis is a life-threatening airway problem. Surgical resection and reconstruction is considered as a preferred therapy for the resectable lesions with tracheobronchial stenoses.[1] For inoperable malignant central airway stenoses, various bronchoscopic treatment modalities have been developed with excellent clinical results.[2-10] Airway stenting has been employed to be an effective treatment modality to relieve the airway obstruction. The most widely used airway stent is the Dumon silicone stent (Endoxane; Novatech; Aubagne, France), which has been used in our institution since 1999. In an attempt to reduce the possible serious major complications related to the use of previous-generation expandable metallic stents, we also have used a new generation of the self-expandable metallic stent (SEMS)-Ultraflex (Boston Scientific; Natick, MA, USA) -since 2001. In this report, we present our experience with the use of Dumon silicone stents and metallic Ultraflex stents in the management of malignant tracheobronchial stenoses.

METHODS

From July 1999 to December 2003, ten patients (7 men, 3 women) with a mean age of 56.3 years (range, 37 to 77 years) had airway stent placement to manage their malignant airway stenoses (Table 1). All patients had severe respiratory distress presenting with the dyspnea

Received: February 10, 2004.
Accepted: July 13, 2004.

Correspondence to: Han Chang, MD, Department of Pathology, Chung-Shan Medical University Hospital, 110, Sec. 1, Chien-Kuo N. Road, Taichung 402, Taiwan.
Tel: +886-4-2473-0022 ext. 1626; Fax: +886-4-2475-6437; E-mail: changhan@csmu.edu.tw

Table 1. Patients treated with airway stents and follow-up

Patient no.	Age	Sex	Underlying malignancy	Site of stenosis	Stent(s) inserted	Change in the dyspnea grade after stenting	Post-stenting treatment	Follow-up (survival months)
1	40	M	Esophageal cancer	Mid-trachea	Dumon, straight	4 → 1	CCRT	Died, (7.3)
2	55	M	Esophageal cancer	Mid-trachea	Dumon, straight	4 → 1	CCRT	Died, (6.6)
3	59	M	Esophageal cancer	LMB	Dumon, straight	3 → 0	CCRT	Alive, (49)
4	65	M	Esophageal cancer	Carina	Dumon, Y-shaped	4 → 4	Nil	Unchanged in the dyspnea grade, Died, (1)
5	48	F	NPC with mediastinal recurrence	Carina	Dumon, Y-shaped	4 → 2	EBRT	Successful ventilator weaning, Died, (5.2)
6	50	M	Recurrent esophageal cancer	LMB and Mid-trachea	Ultraflex, x 2	4 → 2	Nil	Died of arrhythmia after 2nd stenting
7	37	F	Recurrent adenoid cystic carcinoma	Carina and distal trachea	Dumon, Y-shaped + straight	3 → 1	Nil	Died, (17.8)
8	67	M	Metastatic mediastinal lymphadenopathy	Upper trachea	Ultraflex	4 → 1	RT	Died, (2.6)
9	65	M	Esophageal cancer with BEF	LMB	Ultraflex	4 → 2	CT	Died, (3)
10	77	F	Mediastinal multiple myeloma	Distal trachea	Dumon, straight	3 → 1	CT	Alive, (12)

BEF = bronchio-esophageal fistula; CCRT = concurrent chemoradiotherapy; CT = chemotherapy; EBRT = endobronchial brachytherapy; F = female; LMB = left main bronchus; M = male; NPC = nasopharyngeal cancer; RT = radiotherapy.

grade 3 or greater, including 6 patients with stenosis of the trachea or main bronchus caused by esophageal cancer, 1 by nasopharyngeal cancer (NPC) with mediastinal recurrence, 1 by recurrent adenoid cystic carcinoma, 1 by metastatic mediastinal lymphadenopathy and 1 by mediastinal multiple myeloma.

We routinely used a ventilating rigid Efer-Dumon bronchoscope (Efer; La Ciotat, France) for airway assessment and control under general anesthesia. Stenoses were gently dilated by either successively larger bronchoscopes or transluminal angioplasty balloons.[2] Electrocautery (EndoShears; USSC; Norwalk, CT, USA) was used in some patients with intraluminal exophytic neogrowth in addition to dilatation. An appropriate-size Dumon silicone stent or self-expandable metallic Ultraflex stent was placed through the rigid bronchoscope according to the techniques described by Dumon and Colreavy respectively.[11,12]

Respiratory distress status was assessed in the dyspnea index based on 5 grades ranging from 0 to 4 before and after stenting: grade 0, asympotmatic while climbing stairs; grade 1, symptomatic while climbing stairs; grade 2, symptomatic after walking 100 m on flat ground; grade 3, symptomatic with the least effort (talking, getting dressed); grade 4, symptomatic in bed, at rest.[7,8] Routine flexible bronchoscopy was performed 1 week and 1 month after the procedure to check stent position. Aerosols of saline solution and daily respiratory physiotherapy were recommended after the procedure to prevent stent obstruction by secretions.

After Dumon stent insertion, 3 patients received concurrent chemoradiotherapy, 1 received endobronchial brachytherapy and 1 received chemotherapy. After Ultraflex stent insertion, 1 patient received radiotherapy and 1 received chemotherapy.

RESULTS

Dumon stents

Eight stents (4 tracheal, 1 bronchial and 3 Y-shaped) were placed in 7 patients. Four stents were implanted in

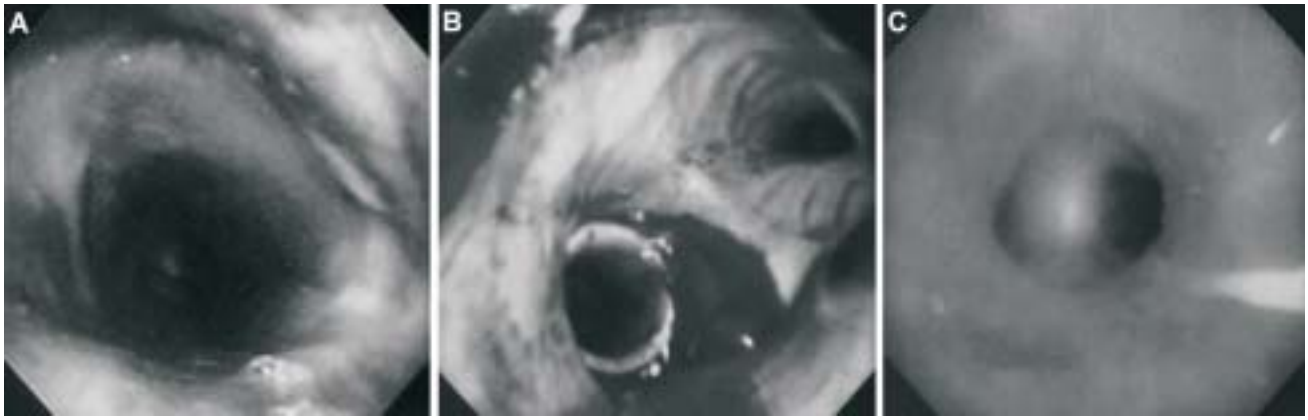

Fig. 1. Dumon stentings. (**A**) One week after a tracheal stent insertion in a 40-year-old male with esophageal cancer and tracheal involvement. (**B**) A bronchial stent was inserted in a 59-year-old male with esophageal cancer and left main bronchial stenosis. (**C**) An Y-shaped stent in a 48-year-old female with NPC with mediastinal recurrence involving the carina. A catheter was placed for endobronchial brachytherapy.

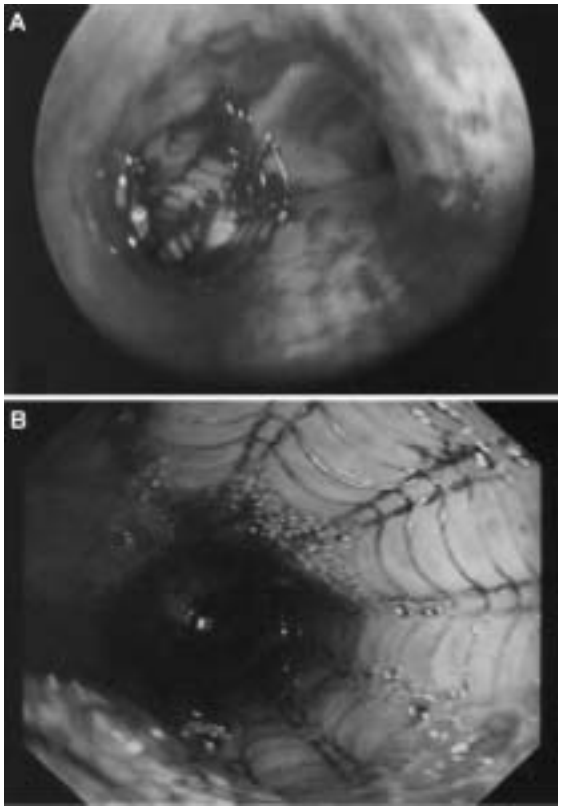

Fig. 2. Ultraflex stentings. (**A**) A bronchial Ultraflex stent was inserted in a 65-year-old male with esophageal cancer and esophageobronchial fistula. (**B**) One week after left main bronchial stenting, the patient received an esophageal stent to seal the fistula. The patient survived 89 days after stenting.

the trachea (Fig. 1A), 1 in the left main bronchus (Fig. 1B) and 3 over the carina. Presenting with troublesome hemoptysis and bilateral obstructive pneumonia, the patient with NPC and mediastinal recurrence involving the carina and both main bronchi received a Y-shaped stent placement and endobronchial brachytherapy (Fig. 1C). She was successfully weaned from mechanical ventilatory support. She was discharged and lived well following the hospitalization. She survived for 5.2 months after stenting. The patient with recurrent adenoid cystic carcinoma involving carina and distal trachea had local tumor progression with recurrence of dyspnea 1 month after an initial Y stent placement. She received another straight tracheal stent thereafter. She survived 18 months after the first stenting.

Ultraflex stents

Four stents (2 tracheal and 2 bronchial) were placed in 3 patients. One patient with esophageal carcinoma involving mid-trachea and left main bronchus had 2 such stents to relieve airway obstruction. However, he died from an aggravated arrhythmia 2 days after his second stent placement. One patient presented with the clinical course of esophageobronchial fistula. One week after insertion of a bronchial Ultraflex stent (Fig. 2A), he also received an esophageal stent to seal the fistula (Fig. 2B).

Efficacy and complications

There was no death related to stent placement, and there were no immediate complications after stenting. Significant improvement of respiratory distress to a

lesser dyspnea grade was seen in 9 patients (90%) after stenting (Table 1). Dyspnea persisted in 1 patient with locally advanced esophageal cancer involving the carina, after insertion of a Dumon Y-shaped stent. The patient died 4 weeks later from progression of the neoplastic disease.

Three stent migrations (25%) were observed in 12 stent placements. One bronchial Dumon stent migration was noted in an esophageal cancer with invasion into the left main bronchus, and the stent was expelled 2 months later because of complete response on concurrent chemoradiotherapy. The other migrated Dumon stent that occurred after 11.5 months post-stenting period was removed easily through the rigid Efer-Dumon bronchoscope in the patient with mediastinal multiple myeloma receiving chemotherapy. In the meanwhile, 1 Ultraflex stent was expelled 2 weeks after stenting in the patient with metastatic mediastinal lymphadenopathy during radiotherapy.

Follow-up and survival

During follow-up to the present time, 1 died of an aggravated arrhythmia 2 days after his second stent placement. The patient with esophageobronchial fistula, receiving double bronchial and esophageal SEMSs to seal the fistula, survived 3 months after his initial bronchial stenting. Seven patients died of disease progression, with a median survival of 5.2 months (range, 1 to 17.8 months) after stenting. Two patients remain alive, with survivals of 49 and 12 months respectively, 1 receiving adjuvant concurrent chemoradiotherapy and the other receiving adjuvant chemotherapy.

DISCUSSION

To manage patients with malignant tracheobronchial stenoses which are not suitable for surgical resection and reconstruction, various bronchoscopic treatment modalities have been developed, including dilatation, laser ablation, mechanical core-out of tumor, endobronchial brachytherapy, and various silicone and metallic stents.[2] These treatment modalities with airway stenting can achieve successful palliation of airway obstruction, relieving respiratory distress in 86-100% of patients.[4,5,7-9]

Among the silicone or metallic stents available, the silicone stent designed by Dumon with a studded surface is the most widely used stent and is removable. The Dumon stent is usually placed through a rigid bronchoscope according to the technique described by Dumon.[11] Recently, some authors reported alternative techniques in Dumon stent placement using a flexible bronchofiberscope or via an endotracheal tube.[13,14] However, the Dumon Y-shaped stent can only be placed through a larger tracheal tube in the rigid Efer-Dumon bronchoscope. In the published reports,[15-17] expandable metallic stents, e.g. the Gianturco-Z stent or the Palmaz stent, have not been advocated due to the possible serious major complications (bronchial perforation, strut fracture) following their placement. To reduce their disadvantages, a new generation of self-expandable metallic stents (SEMS)-Ultraflex (bared or covered version with polyurethane membrane)-has been recently developed by Boston Scientific Ltd. The Ultraflex stent can be inserted by a pulmonologist or interventional radiologist, using a flexible bronchoscope and topical anesthesia under fluoroscopic guidance.[7,10,17] To secure the airway condition in such patients with respiratory distress, airway stenting is still recommended through a ventilating rigid bronchoscope under surveillance of an anesthesiologist, as reported presently.

In our experience, significant improvement of respiratory distress to a lesser dyspnea grade was seen in all patients except 1 with locally advanced esophageal cancer after insertion of a Dumon Y-shaped stent. Very few immediate complications were reported after Dumon and Ultraflex stent placements for malignant stenoses.[3,12] However, late complications of the Dumon stent insertion are frequently encountered, including stent migration (9-24%), granuloma formation (3-7.9%) and stent obstruction due to voluminous airway secretion (6.3%).[3,4,18-20] On the other aspect of the SEMS placement, Saas *et al.* reported their 6-year experience implanting 112 self-expandable metallic Wallstent or Ultraflex stents.[10] The observed complications included infection (15.9%), obstructive granuloma (14.6%) and migration (4.7%). In our report, stent migration appears to be a frequent late complication. Dumon stent migration was observed in 2 patients during adjuvant therapy. One Ultraflex stent migration was observed to be related to undersizing of the stent diameter. To

lower stent migration after airway stenting and to improve rigidity and wall thickness, a few newly designed silicone stents have been developed to yield better results.[18,21,22]

In patients with malignant esophageorespiratory fistula, double stenting has been advocated to seal the fistulas because of insufficient sealing and persistent aspiration by a single stent insertion. These patients can benefit from relief of dyspnea and dysphagia and improve survival time.[23,24] However, Tomaselli *et al.* reported their successful sealing of malignant esophageotracheal fistula in 6 patients by using an esophageal covered Ultraflex stent. The median survival of the 5 patients who died was 78 days.[25] In our case with esophageobronchial fistula that was caused by esophageal cancer, we employed double stenting to relieve the left main bronchial obstruction and to seal the fistula. He survived 3 months after his initial bronchial stenting. To relieve the airway obstruction and to seal the esophageorespiratory fistula, double stenting might be a preferable endoscopic treatment modality.

Among 10 patients with malignant stenoses in our report, we obtained comparably successful palliation and prolonged survival using 8 Dumon stents (5 straight and 3 Y-shaped) and 4 Ultraflex stents.[4,9,26] Seven patients died of disease progression, with a median survival of 5.2 months (range, 1 to 17.8 months) after stenting. Two Dumon stent migrations that occurred during adjuvant therapy might disclose good treatment response for their underlying malignancies. These 2 patients remain alive, with survivals of 49 and 12 months respectively.

In general consideration of indications for different airway stents, the Dumon silicone stents can be used in the treatment of malignant stenoses, benign postintubation or posttracheostomy stenoses, tuberculous stenoses,[27] and post-lung transplantation anastomotic stenoses.[3] The Dumon Y-shaped stents are also of value in providing good palliation for malignan stenoses involving the carina. Recently, the SEMS has gained increasing interest in managing airway problems. Like the silicone stents, the SEMS is also an acceptable therapeutic alternative in patients with malignant stenoses.[2,10,12] During this time, Chhajed *et al.* presented their experience with the use of the Ultraflex stents and found that the stents appeared to have fewer long-term complications when used in the management of airway complications following lung transplantation.[28] Kumar *et al.* also reported encouraging medium-term results after stenting with SEMS for pediatric tracheobronchial obstruction due to vascular compression.[29] However, some authors have mentioned SEMS should be avoided in the benign postintubation stricture because of its difficulty in removal and severe airway luminal injury after a short duration of stenting.[12,30]

Comparing the other different features in clinical uses between Dumon silicone stents and metallic Ultraflex stents (Table 2), the Dumon stents are easy to insert, to adjust and to remove through a rigid Efer-Dumon bronchoscope. They can be removed after a long-term duration of stenting in treating benign airway stenoses. Y-shaped

Table 2. Comparison of clinical uses between Dumon silicone stents and metallic Ultraflex stents

Type of stent	Indications for underlying etiologies	Placement technique	Advantages	Disadvantages
Dumon stents	Malignant stenoses Postintubation or posttrachesotomy stenoses Tuberculous stenoses Post-lung transplantation anastomotic stenoses Stenoses in the carinal region	Via a rigid Efer-Dumon bronchoscope	Easy to insert, adjust and remove Y-shaped stent available	Relatively thick wall of the stent Lack of flexibility in the airway Higher stent migration
Ultraflex stents	Malignant stenoses Post-lung transplantation anastomotic stenoses Pediatric airway stenoses by vascular compression	Via a rigid or flexible bronchoscope	Easy to insert Less stent migration	Y-shaped stent not available Difficult to remove Higher airway obstruction by tumor ingrowth and granuloma

stents are also available in Dumon type, but not in Ultraflex. The Ultraflex stents can be easily inserted using a rigid or flexible bronchoscope, whereas they are difficult to remove. After stenting, relatively higher migration may occur in Dumon stents than in Ultraflex stents; however, airway obstruction by tumor ingrowth or granuloma is more frequently found after insertion of Ultraflex stents than when using Dumon stents.

In conclusion, airway stenting in bronchoscopic treatment modalities has now become a valuable and established alternative in the management of malignant stenoses. Selection of an airway stent by the operators depends on its indication, availability of a rigid bronchoscope and familiarity with the interventional procedures. The insertion of airway stents, either Dumon stents or Ultraflex stents, is technically easy and safe. Their use can provide an effective method to immediately relieve respiratory distress, to improve the quality of life and to prolong survival in patients with malignant central airway stenoses.

ACKNOWLEDGEMENTS

This study was supported in part by grants (CSMU 89-OM-B-001; CSMU 88-OM-B-026) from Chung-Shan Medical University, Taichung, Taiwan, R.O.C.

REFERENCES

1. Grillo HC. Surgical anatomy of the trachea and techniques of resection. In: Thomas WS, Joseph LIII, Ronald BP, eds. *General thoracic surgery.* 5th ed. Philadelphia: Lippincott, Williams & Wilkins, 2000:873-83.
2. Stephens KE Jr, Wood DE. Bronchoscopic management of central airway obstruction. *J Thorac Cardiovasc Surg* 2000; 119:289-96.
3. Dumon JF, Cavaliere S, Diaz-Jimenez JP, Vergnon JM. Seven year experience with the Dumon prosthesis. *J Bronchol* 1996; 3:6-10.
4. Belleguic C, Lena H, Briens E, Desrues B, Bretagne JF, Delaval P, Kernec J. Tracheobronchial stenting in patients with esophageal cancer involving the central airways. *Endoscopy* 1999;31:232-6.
5. Bolliger CT, Probst R, Tschopp K, Soler M, Perruchoud AP. Silicone stents in the management of inoperable tracheobronchial stenoses. *Chest* 1993;104:1653-9.
6. Abdullah V, Yim AP, Wormald PJ, van Hasselt CA. Dumon silicone stents in obstructive tracheobronchial lesions: the Hong Kong experience. *Otolaryngol Head Neck Surg* 1998; 118:256-60.
7. Hsu LH, Liu CC, Lin CY, Yen KL, Chan KY. Self-expandable metallic tracheobronchial stent insertion and endobronchial electrocautery with flexible bronchoscopy: preliminary results at a cancer center. *J Formos Med Assoc* 2002;101: 399-405.
8. Monnier P, Mudry A, Stanzel F, Haeussinger K, Heitz M, Probst R, Bolliger CT. The use of the covered Wallstent for the palliative treatment of inoperable tracheobronchial cancers. *Chest* 1996;110:1161-8.
9. Tojo T, Iioka S, Kitamura S, Maeda M, Otsuji H, Uchida H, *et al*. Management of malignant tracheobronchial stenosis with metal stents and Dumon stents. *Ann Thorac Surg* 1996;61: 1074-8.
10. Saad CP, Murthy S, Krizmanich G, Mehta AC. Self-expandable metallic airway stents and flexible bronchoscopy: long-term outcome analysis. *Chest* 2003;124:1993-9.
11. Dumon JF. A dedicated tracheobronchial stent. *Chest* 1990; 97:328-32.
12. Colreavy MP, Keogh I, Hone S, Lacy PD, Gaffney RJ, Walsh MA. Nitinol stents: their value in tracheobronchial obstruction. *Clin Otolaryngol* 2000;25:233-9.
13. Watanabe SI, Sakasegawa KI, Nakamura Y, Kariatsumari K, Suehiro S, Shimokawa S, Sakata R. Placement of the Dumon stent using a flexible bronchofiberscope via tracheostomy. *Thorac Cardiovasc Surg* 2003;51:231-4.
14. Nomori H, Horio H and Suemasu K. Dumon stent placement *via* endotracheal tube. *Chest* 1999;115:582-3.
15. Varela A, Maynar M, Irving D, Dick R, Reyes R, Rousseau H, *et al*. Use of Gianturco self-expandable stents in the tracheobronchial tree. *Ann Thorac Surg* 1990;49:806-9.
16. Wadsworth SJ, Juniper MC, Benson MK, Gleeson FV. Fatal complication of an expandable metallic bronchial stent. *Br J Radiol* 1999;72:706-8.
17. Rafanan AL, Mehta AC. Stenting of the tracheobronchial tree. *Radiol Clin North Am* 2000;38:395-408.
18. Noppen M, Meysman M, Claes I, D'Haese J, Vincken W. Screw-thread *vs* Dumon endoprosthesis in the management of tracheal stenosis. *Chest* 1999;115:532-5.
19. Yim AP, Abdullah V, Izzat MB, van Hasselt CA. Video-assisted interventional bronchoscopy: the Hong Kong experience. *Surg Endosc* 1998;12:444-7.
20. Martinez-Ballarin JI, Diaz-Jimenez PJ, Castro MJ, Moya JA. Silicon stents in the management of benign tracheobronchial

stenoses. *Chest* 1996;109:626-9.
21. Vergnon JM, Costes F, Polio JC. Efficacy and tolerance of a new silicone stent for the treatment of benign tracheal stenosis. *Chest* 2000;118:422-6.
22. Wassermann K, Koch A, Muller-Ehmsen J, Reuter M, Michel O, Eckel HE. Clinical and laboratory evaluation of a new thin-walled self-expanding tracheobronchial silicone stent: progress and pitfalls. *J Thorac Cardiovasc Surg* 1997;114: 527-34.
23. Freitag L, Tekolf E, Steveling H, Donovan TJ, Stamatis G. Management of malignant esophagotracheal fistulas with airway stenting and double stenting. *Chest* 1996;110:1155-60.
24. van den Bongard HJ, Boot H, Baas P, Taal BG. The role of parallel stent insertion in patients with esophagorespiratory fistulas. *Gastrointest Endosc* 2002;55:110-5.
25. Tomaselli F, Maier A, Sankin O, Woltsche M, Pinter H, Smolle-Juttner FM. Successful endoscopical sealing of malignant esophageotracheal fistulae by using a covered self-expandable stenting system. *Eur J Cardiothorac Surg* 2001;20: 734-8.
26. Wassermann K, Eckle HE, Michel O, Muller RP. Emergency stenting of malignant obstruction of the upper airways: long-term follow-up with 2 types of silicone prosthesis. *J Thorac Cardiovasc Surg* 1996;112:859-66.
27. Wan IY, Lee TW, Lam HC, Abdullah V, Yim AP. Tracheobronchial stenting for tuberculous airway stenosis. *Chest* 2002;122:370-4.
28. Chhajed PN, Malouf MA, Tamm M, Glanville AR. Ultraflex stents for the management of airway complications in lung transplant recipients. *Respirology* 2003;8:59-64.
29. Kumar P, Bush AP, Ladas GP, Goldstraw P. Tracheobronchial obstruction in children:experience with endoscopic airway stenting. *Ann Thorac Surg* 2003;75:1579-86.
30. Gaissert HA, Grillo HC, Wright CD, Donahue DM, Wain JC, Mathisen DJ. Complication of benign tracheobronchial stricture by self-expanding metal stents. *J Thorac Cardiovasc Surg* 2003;126:744-7.