Pergamon

European Journal of Cancer Vol. 33, No. 2, pp. 204–208, 1997

Printed in Great Britain
0959-8049/97 $17.00 + 0.00

PII: S0959-8049(96)00350-4

Original Paper

Temporary Tracheobronchial Stenting in Malignant Stenoses

Ch. Witt,[1] S. Dinges,[2] B. Schmidt,[1] R. Ewert,[1] V. Budach[2] and G. Baumann[1]

[1]Department of Internal Medicine I, Division of Pneumology; and [2]Department of Radiotherapy, Medical School (Charité), Humboldt University, Schumannstr 20/21, Berlin D-10117, Germany

Endobronchial stent implantation has been successfully employed in malignant stenoses. The aim of this prospective study was to investigate the temporary use of tracheobronchial stents combined with tumour-specific therapy. All patients received stents for primary palliation of dyspnoea followed by radio- or chemotherapy with the aim of stent removal after reduction of the stenosis. In 22 patients suffering from severe malignant strictures, 34 endobronchial stents (29 Strecker-, 3 Dumon-, 1 Orlowski-, 1 Dynamic-Y-stents) were implanted (in 9 patients, 2 stents were necessary). Patients were treated by irradiation ($n = 18$) or chemotherapy ($n = 4$) after stent implantation. Significant improvement of dyspnoea ($P < 0.001$) and partial oxygen pressure ($P < 0.01$) was observed. In 11 out of 22 cases (50%), the stents could be removed after successful tumour-specific therapy which led to reduction of stenosis after a mean interval of 31.7 (6–104) days (temporary stenting). During the period of tumour-specific therapy, 9 patients died after a mean interval of 132 (13–347) days (definite stenting). In two cases, stents had to be removed after stent compression, stent dislocation and severe cough. The results suggest that temporary stenting, characterised by subsequent successful tumour-specific therapy, is a new valuable therapeutic strategy. It can "bridge the gap" before tumour-specific therapy can take effect. If tumour-specific therapy is ineffective, definite stenting is the palliative method of choice in severe dyspnoea in bronchial carcinoma.

Key words: temporary stenting, malignant stenoses, stent, interventional pneumology

Eur J Cancer, Vol. 33, No. 2, pp. 204–208, 1997

INTRODUCTION

AIRWAY OBSTRUCTION caused by malignant tumours is a respiratory emergency. Apart from laser therapy (Nd:YAG laser) for exophytic tumour growth, stent implantation has become the method of choice to relieve patients of severe dyspnoea.

Since Montgomery developed a first tracheal T-stent in 1965 [1], several stent types have been used: Dumon introduced short silicone stents for use in the trachea and main bronchi in 1990 [2], Orlowski (1987) [3] and, more recently, Freitag and associates (1992) [4] developed reinforced silicone stents. Metallic stents have primarily been used in arteries [5–7]. The successful use of self-expandable metallic stents (Gianturco-Z-stent, Wallstent) in the tracheobronchial system was first described in 1986 [8], followed by another report in 1991 [9].

Today, the balloon-expandable Strecker device, based on the expansion of a wire mesh placed around a dilatation balloon, is mostly used. After dilatation by balloon pressure the stent remains in a stable position. Major advantages of metallic stents and particularly of Strecker stents [10] are the maintenance of mucociliary clearance in the stent region [11, 12], dynamic behaviour and stable position. Apart from the high cost, a major disadvantage of metallic stents, in long-term stenting, is the penetration of tissue through wire meshes.

As for implantation techniques, rigid bronchoscopy has primarily been used for both silicone and metallic stents. Recent publications show that metallic stents can also be implanted by flexible bronchoscopy with local anesthaesia [12, 13].

General side-effects of tracheobronchial stenting are the reduction of mucociliary clearance which may lead to se-

Correspondence to Ch. Witt.
Received 9 Feb. 1996; revised and accepted 27 Aug. 1996.

crete retention, severe cough and bronchial obturation [2, 10]. Furthermore, the stent itself being a foreign body can cause irritation of the mucosa. The major complication after stent implantation is dislocation of the prosthesis and blockage of the airways. The risk of dislocation is especially high when tumour-specific therapy is effective and leads to reduction of stenosis. In order to minimise those risks and side-effects in pulmonary oncology, temporary stenting might be a valuable strategy.

Thus far, stent implantation in pulmonary oncology has been used as a definite palliative procedure when tumour-specific therapy has not been effective or carried out (definite stenting). The aim of this prospective study was to investigate a new strategy in the use of tracheobronchial stents. Patients received stents as primary palliation of dyspnoea followed by tumour-specific therapy. Stenting was thus a bridging-method until radio- or chemotherapy could take effect. The aim was to determine whether tumour-specific therapy could sufficiently reduce the tumour-related stenosis to permit removal of the stent (temporary stenting).

PATIENTS AND METHODS

Patients

22 patients (between 35 and 74 years) suffering from severe tumourous stenoses, who presented with severe dyspnoea (life-threatening dyspnoea in 81%) and inspiratory stridor, were treated by endobronchial stent implantation. The diagnoses were bronchial carcinoma ($n = 17$), lymphoma ($n = 3$; life-threatening dyspnoea) and metastases of extrathoracic carcinoma ($n = 2$). All patients with malignant stenoses of central airways who received tracheobronchial stents and subsequently tumour-specific therapy between 1992 and 1994 were included in the study. Excluded were all patients where further therapy was not possible (e.g. patients who had already undergone maximum irradiation or patients in a clinical state which did not permit any further treatment).

Methods

Stent implantation. Patients underwent clinical, radiological and bronchological diagnostic procedures and — if possible — lung function tests were performed. In addition to measuring the stenotic area under direct vision at fibrebronchoscopy, a bronchus tomogram was conducted to examine the length and course of the stenotic area. This determined the number and size of the stents to be implanted. If the stenotic region could not be completely bridged, an additional stent was inserted. The metallic stents were implanted by means of fibrebronchoscopy under local anaesthaesia. The silicone stents were implanted by rigid bronchoscopy as described by Dumon [2], Orlowski [3], and Freitag and associates [13]. Stent extraction was performed with simple forceps, when the stents loosened at bronchoscopic control.

The stents used were balloon-expandable Strecker stents (Boston Scientific, U.S.A.), Dumon stents (axion pour la vie S.a.r.l., France), Orlowski stents (Rüsch AG, Germany) and Dynamic (Freitag) stents (Rüsch AG, Germany).

Assessment of clinical outcome. Immediately after stent implantation, recanalisation was verified by endoscopic means in each case. The dyspnoea score of Watters and associates [14], classifying dyspnoea from 0 (no dyspnoea) to 20 (dyspnoea at rest), was employed before and after stenting. Blood gases were taken in every case before and after stent insertion. Spirometry could only be performed in 6 cases, as all other patients were too ill (in respiratory emergency) to undergo testing. Following stent insertion, bronchoscopic follow-up controls were routinely performed every week.

After stent implantation, the patients received tumour-specific therapy (Tables 1 and 2) in order to reduce airway

Table 1. Results of stenting: in 11 cases, tumour-specific therapy was effective in reduction of stenosis

Patient no.	Age/sex	Histology	Stenotic region	M	S	Tumour-specific therapy	Afterloading dose	Ext. beam dose	Time until removal (days)	Note
1	52/m	NSCLC	Tr/rMB	2	0	ext. beam irradiation		36 Gy	23 (Tr), 37 (rMB)	
3	54/m	NSCLC	lMB	1	0	afterloading	3 × 5Gy		8	
4	61/m	NSCLC	lMB	1	0	afterloading	2 × 10Gy	–	104	
5	35/m	SCLC(r)	Tr/rMB	2	0	ext. beam irradiation		12 Gy	20 (Tr), 41 (rMB)	restenosis after stent extraction (116d)
6	42/m	NSCLC	Tr/lMB	2	0	combined irradiation	1 × 10Gy	54 Gy	44 (Tr), 44 (lMB)	
7	55/m	NSCLC	lMB	1	0	ext. beam irradiation		31 Gy	25	
8	49/m	NSCLC	rMB/lMB	2	0	afterloading	1 × 10Gy + 1 × 5Gy		19 (rMB), 62 (lMB)	
9	74/m	NSCLC	rMB	1	0	ext.beam irradiation		46 Gy	47	
12	68/m	SCLC	lMB	1	0	chemotherapy (ICE)			18	
13	37/f	lymphoma	rMB/lMB	2	0	ext.beam irradiation		9 Gy	6 (rMB), 13 (rMB)	
21	64/f	M. Hodgkin	rMB/lMB	1	1	chemotherapy (COPP/ABV)			14 (rMB), 14 (lMB)	

NSCLC, non-small-cell carcinoma; SCLC, small cell carcinoma; thyr. ca, thyroid carcinoma; Tr, trachea; rMB, right main bronchus; lMB, left main bronchus; int.br., intermediate bronchus; M, metallic stent; S, silicone stent; r, recurrence; ext, external; ICE, ifosfamide–cisplatin–etopside, COPP/ABV, cyclophosphamide, vincristine, procarbazine, prednisone, doxorubicin, bleomycin, vinblastine.

Table 2. Results of stenting: in 11 cases tumour-specific therapy was not effective in reduction of stenosis

Patient no.	Age/sex	Histology	Stenotic region	M	S	Tumour-specific therapy	Afterloading dose	Ext. beam dose	Time until removal (days)	Note
Definite stenting										
2	63/m	NSCLC	lMB	1	0	afterloading	4 × 5Gy		13	osseous metastases
10	63/m	lymphoma	lMB	1	0	combined irradiation	4 × 5Gy	59.4 Gy	47	fistula
11*	53/m	NSCLC	rMB	1	0	afterloading	3 × 5Gy		136	
			lMB	0	1					1 silicone stent (left) removed after dislocation
14	58/m	SCLC(r)	int.br.	1	0	afterloading	4 × 5Gy		203	
17	62/f	NSCLC	lMB	1	0	ext.beam irradiation	–	40 Gy	99	brain metastases
18	61/m	NSCLC	lMB	1	0	combined irradiation	2 × 5Gy	60 Gy	145	pulmonary bleeding
19	58/m	NSCLC	Tr	0	1	combined irradiation	5 × 5Gy	60.75 Gy	158	
			lMB/rMB	4	0					4 metallic stents replaced by one bifurcated silicone stent
20	55/m	NSCLC	Tr	0	1	chemotherapy (ICE)			347	
22	66/f	SCLC	int.br.	1	0	chemotherapy (ICE)			40	lung metastases
Complications										
15	61/m	NSCLC	int.br.	1	0	combined irradiation	4 × 5Gy	66.6 Gy	238	severe cough
16	56/f	thyr.ca (met)	rMB/lMB	1	1	radio-iodine therapy			7(1MB)	compression of Strecker device
									1(1MB)	dislocation of Dumon device

For definition of abbreviations, see footnotes to Table 1.

stenosis and subsequently to remove the stent (temporary stenting), which was the aim in each case.

The primary endpoint of this study was either the removal of the stent, once tumour-specific therapy had been effective, or patient death.

RESULTS

In 22 patients, a total of 34 stents was implanted (29 Strecker-, 3 Dumon-, 1 Orlowski-, 1 Dynamic [Freitag-]-stents). In 9 cases, the implantation of 2 stents at the same intervention was necessary, in 4 of these patients (patients 11, 16, 19 and 21), silicone and metal stents were used together. In one case, additional metallic stents had to be implanted after Strecker-stent compression at a second innervation (patient 19). Silicone stents were used in the trachea ($n = 2$), main carina, and main bronchi ($n = 3$), whereas metal stents were mostly implanted in the main bronchi (right main bronchus $n = 11$, left main bronchus $n = 12$), in distal airways (intermediate bronchus $n = 3$), and less often in the trachea ($n = 3$).

Stent implantation was successful in every case in terms of reducing stridor and attenuating dyspnoea ($P < 0.001$). Partial oxygen pressure increased significantly after stent implantation ($P < 0.01$; Figure 1). A significant improvement

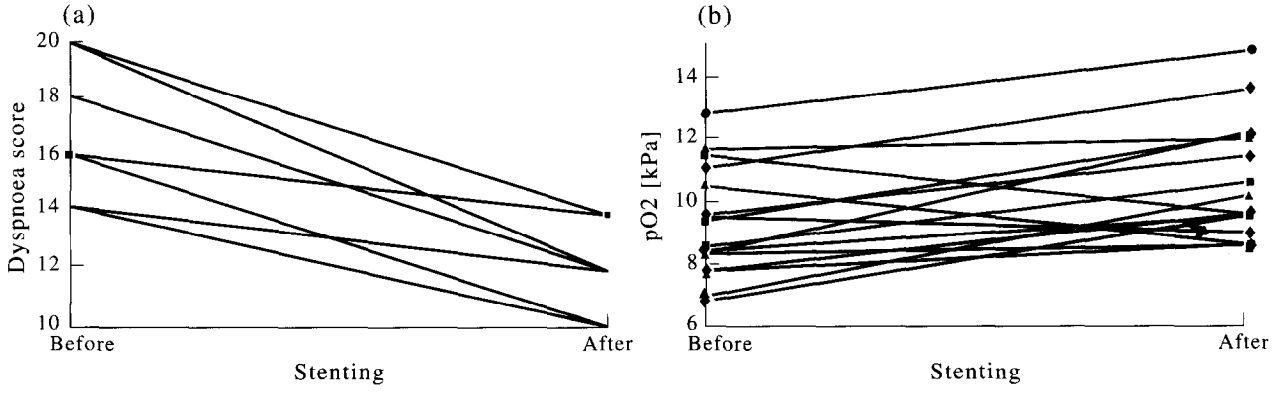

Figure 1. Dyspnoea before and after stenting ($P < 0.001$: according to score of Watters and associates [14]) and arterial partial oxygen pressure before and after stent implantation ($P < 0.01$).

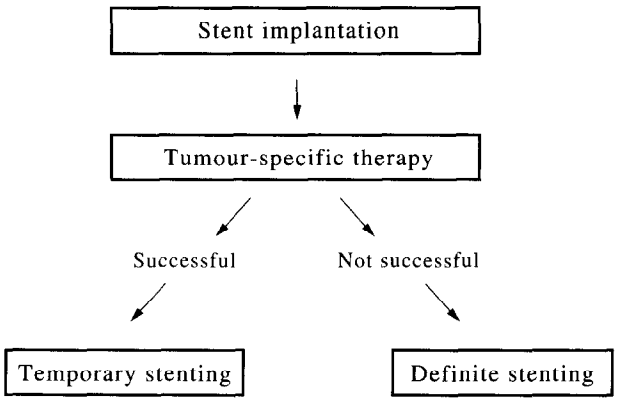

Figure 2. Therapeutic strategy for airway blockage.

of spirometry results could not be observed in the 6 tested patients. There were no complications during stent implantation. Neither mucous retention nor reobstruction caused by tissue-penetrating metallic stents were observed in stented patients.

17 out of 22 patients received radiotherapy. Patients (pts.) were irradiated either percutaneously (6 out of 17 pts., 6–9 MV photons of a linear accelerator or 43 MV photons of a betatron®) or with high-dose-rate brachytherapy (6 out of 17 pts., ^{192}Iridium source, 10 Ci, remote afterloading system) or with a combination of both treatment modalities (5 out of 17). The percutaneous dose ranged from 25 Gy/5 fractions (fx) to 66.6 Gy/37fx. Using the linear quadratic model and an α/β ratio of 3 Gy for late effects, the percutaneous dose ranged from 40 to 68.7 Gy. Brachytherapy single doses ranged from 10Gy/2fx to 25Gy/5fx in 5 or 10 mm depth of tissue and was given alone or a boost after percutaneous irradiation (see Tables 1 and 2).

Chemotherapy was given to 2 patients suffering from small cell lung carcinoma (SCLC) using ifosfamide (2000 mg/m^2, days 1–5), etopside (120 mg/m^2, days 1–3), and cisplatin (60 mg/m^2, day 1) (ICE). The same protocol was employed in 1 patient with non-small cell lung carcinoma (NSCLC), who did not accept irradiation (No. 20). In one case of Hodgkin's disease (No. 21), the COPP/ABV schedule was employed (cyclophosphamide 650 mg/m^2, days 1 + 8; vincristine 1.4 mg/m^2, day 1; procarbazine 100 mg/m^2, days 1–7; prednisone 40 mg/m^2, days 1–14; doxorubicin 35 mg/m^2, day 8; bleomycin 10 mg/m^2, day 8; vinblastine 6 mg/m^2, day 8). One patient received radio-iodine therapy.

Tumour-specific therapy did not disturb stent toleration and did not lead to its dislocation. The stent was incorporated into the bronchial mucosa without any relevant visible irritation during the period of therapy.

In 50% (11 out of 22) cases, the stent could easily be removed (temporary stenting) by fibre-optic bronchoscopy and foreign-body forceps, after a mean interval of 31.7 days (6–104 days) after successful tumour-specific therapy had led to reduction of stenosis. In patients treated by external beam irradiation, the mean time to removal of the stent was 26.5 days (6–47 days). It was 48.3 days (8–104 days) in patients with afterloading, 44 days in the patient with combined irradiation, and 15.3 days in patients who received chemotherapy (14–18 days). External beam irradiation was successful in 5 out of the 6 patients, whereas successful afterloading therapy could be observed in 3 out of 6 patients. Combined irradiation was successful in 1 out of 5 patients (Table 1).

Restenosis at the stented site occurred in only 1 patient (No. 5) 116 days after stent extraction which made restenting necessary. The patient died 15 days later due to massive pulmonary haemorrhage.

In 11 cases (50%) temporary stenting, defined as removal of stents after successful tumour-specific therapy, was impossible (Table 2): 9 patients died while they were receiving radio- or chemotherapy 13–347 days (mean 132 days) after the stent had been inserted. By definition, this meant the stent insertion was regarded as 'definite stenting.' In one of these patients, a silicone stent had to be removed after dislocation, while a metallic stent remained in place (No. 11); in another patient, four metallic stents were exchanged for one bifurcated silicone stent (No. 19). In two cases stents, had to be removed after severe cough, stent compression and stent dislocation (Nos. 15 and 16).

DISCUSSION

Tracheobronchial stent implantation has been successfully employed in patients with malignant airway stenoses. It is a safe method to avert the danger of asphyxia caused by tumourous strictures [15–19]. For ethical reasons, our study design lacks a randomised control group, and individual clinical outcomes were used to assess improvement of patients' quality of life. The study did not examine prolongation of patient survival. Bolliger and associates [20] and Carrasco and associates [21] observed short mean or median survivals (2–3 months) after stent implantation. The relatively long survival of our patients might be due to the fact that we implanted stents at an early stage, while others use stents as the last resort. We feel that stent implantation should become an integrated part of tumour-specific therapies of bronchial carcinoma.

In addition to the recanalisation of the bronchial system with immediate subsequent improvement of the respiratory function [22] and prevention of pneumonia, tumour-specific treatment can be applied under satisfactory respiratory conditions. Stent application prevents asphyxia if oedema occurs during radiotherapy. The afterloading the catheter can easily be introduced into the stented region. When subsequent tumour-specific therapy is effective, reduction of stenosis permits removal of the stent (temporary stenting), which was the case in 50% of patients in this study. Therapeutic success was mostly assessed in patients where external beam irradiation or combined irradiation was still possible (5/6 patients versus only 3/6 patients with afterloading), and these were patients without previous maximum irradiation. Afterloading was only used if external beam irradiation was impossible.

This leads to the conclusion that temporary stenting can be more successful in cases without irradiation before stenting than in patients who have already undergone tumour-specific therapy. However, even if tumour-specific therapy is ineffective in reducing the stenosis, it might prevent tumour penetration through the stent. In all patients who died before stent removal, stenting had been conducted with palliative intent.

Even if penetration did not occur in our patients, it remains a possibility, so metallic devices would better be

avoided in long-term stenting. If the duration of stenting is longer than expected, a change of the type of stent from metallic device to silicone or covered metallic stents may be necessary. For PUR-covered stents, no long-term experiences have as yet, been published. The Strecker device, which has been used in this study, seems to be perfectly adequate for temporary stenting. Its implantation is relatively simple and the stent loosens relatively easily once the tumour is reduced in size. This is a clear advantage of self-expandable metallic stents. Concerning the implantation technique many authors use rigid bronchoscopy to insert metallic stents [8, 15–18], but we used fibre-bronchoscopy successfully for Strecker-stent insertion. It is more comfortable to the patient and easier to perform. The choice of bronchoscopic method — rigid or flexible — finally depends on the experience and preference of the physician.

However, the results of this study suggest that temporary stenting, followed by tumour-specific therapy, is a new valuable therapeutic strategy in a multitherapy concept. Where tumour-specific therapy is ineffective, definite stenting remains the palliative method of choice in malignant tracheobronchial stenoses (Figure 2).

1. Montgomery WW. T-Tube tracheal stent. *Arch Otolaryngol* 1965, **82**, 320–321.
2. Dumon JF. A dedicated tracheobronchial stent. *Chest* 1990, **97**, 328–332.
3. Orlowski TM. Palliative intubation of the tracheobronchial tree. *J Thorac Cardiovasc Surg* 1987, **94**, 343–348.
4. Freitag L, Mohnke M, Eiker R, Linz B, Greschuchna D. Implantation of 156 airway stents of seven types in 94 patients and development of a new dynamic stent. *Am Rev Resp Dis* 1992, **145**(4), A509.
5. Wright K, Wallace S, Charnsangavej C, Carrasco H, Gianturco C. Percutaneous endovascular stents: an experimental evaluation. *Radiology* 1985, **156**, 69–72.
6. Sigwart U, Puel J, Mikovitch V, Joffre F, Kappenberger L. Intravascular stents to prevent occlusion and restenosis after transluminal angioplasty. *N Engl J Med* 1987, **316**, 701–706.
7. Strecker EP, Liermann D, Barth KH, *et al.* Expandable tubular stents for treatment of arterial occlusive diseases: experimental and clinical results. *Radiology* 1990, **175**, 87–102.
8. Wallace MJ, Charnsangavej C, Ogawa K, *et al.* Tracheobronchial tree: expandable metallic stents used in experimental and clinical applications. *Radiology* 1986, **158**, 309–312.
9. Bohndorf K, Günther RW, Hürter T, *et al.* Implantation selbstexpandierender Metallprothesen (Stents) in Bronchialsystem bei zentralen Neoplasien. *Fortschr Röntgenstr* 1991, **155**, 223–227.
10. Breyer G, Häußinger K. Tracheobronchiale Stents—Indikationen und Möglichkeiten. *Pneumologie* 1991, **45**, 997–1003.
11. Rousseau H, Dahan M, Lauque D, *et al.* Self-expandable protheses in the tracheobronchial tree. *Radiology* 1993, **188**, 199–203.
12. Coolen D, Slabbynck H, Galdermans D, van Schaardenburg C, Mortelmans L. Insertion of a self-expandable metallic stent using topical anesthesia and a fibreoptic bronchoscope: a comfortable way of offer palliation. *Thorax* 1994, **49**, 87–88.
13. Freitag L, Tekolf E, Anweiler H, *et al.* Interventionelle Bronchologie in der palliativen Behandlung des Bronchialkarzinoms. *Tumordiagn u Ther* 1993, **14**, 83–90.
14. Watters L, King T, Schwarz M, Waldron J, Stanford R, Cherniack R. A clinical radiographic, and physiologic scoring system for the longitudinal assessment of patients with idiopathic pulmonary fibrosis. *Am Rev Resp Dis* 1986, **133**, 97–103.
15. Varela A, Maynar M, Irving D, *et al.* Use of Gianturco self-expandable stents in the tracheobronchial tree. *Ann Thorac Surg* 1990, **49**, 806–809.
16. George PJM, Irving JD, Mantell BS, Rudd RM. Covered expandable metal stent for recurrent tracheal obstruction. *Lancet* 1990, **335**, 582–584.
17. Cooper JD, Person FG, Patterson GA, *et al.* Use of silicone stents in the management of airway problems. *Ann Thorac Surg* 1989, **47**, 371–378.
18. Gaer JAR, Tsang V, Khaghani A, *et al.* Use of endotracheal silicone stents for relief of tracheobronchial obstruction. *Ann Thorac Surg* 1992, **54**, 512–516.
19. De Souza A, Keal R, Hudson NM, Leverment JN, Spyt TJ. Use of expandable wire stents for malignant airway obstruction. *Ann Thorac Surg* 1994, **57**, 1573–1578.
20. Bolliger CT, Probst R, Tschopp K, Soler M, Perruchoud AP. Silicone stents in the management of inoperable tracheobronchiale stenoses—indications and limitations. *Chest* 1993, **104**, 1653–1659.
21. Carrasco CH, Nesbitt JC, Charnsangavej C, *et al.* Management of tracheal and bronchial stenoses with the Gianturco stent. *Ann Thorac Surg* 1994, **58**, 1012–1017.
22. Gelb AF, Zamel N, Colchen A, *et al.* Physiologic studies of tracheobronchial stents in airway obstruction. *Am Rev Respir Dis* 1992, **146**, 1088–1090.