Preliminary Experience with Bronchotherapeutic Procedures in Central Airway Obstruction

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Background: Central airway obstruction is still challenging to physicians. We herein report on our experiences with bronchotherapeutic procedures over a recent 8-month period.

Methods: From January 2002 to August 2002, 21 patients received 26 procedures (4 core outs, 6 dilations, 13 stent placements, 2 biopsies, and 1 foreign body removal). All patients were treated with or assisted using a rigid bronchoscope technique, except in 1 case in which a fiber bronchoscope was used. The etiologies included 4 cases of lung cancer, 3 cases of malignancy-related tracheoesophageal fistula, 6 cases of airway intubation, 2 cases of laryngotracheal tuberculosis, 1 case of post-anastomotic stenosis, 1 case of laryngotracheal trauma, 1 case of subglottic web, 1 case of foreign body, and 2 cases of unknown origin.

Results: Seventeen patients receiving bronchotherapeutic procedures benefited from the procedures, with 2 complications occurring in our series. One patient who was 87 years old with esophageal cancer and tracheoesophageal fistula died 5 days after the operation. Stent-related complications occurred in 2 patients (1 collapse by compression and 1 mucous obstruction). No airway laceration occurred while performing the procedure. Two instances of intraoperative bleeding were encountered, which were successfully controlled by compression of the lesion using the side of the rigid bronchoscope.

Conclusions: In malignant airway obstructions, we resected the endobronchial tumor with the tip of the rigid bronchoscope. Stents were reserved for patients with residual obstruction or severe extrinsic compression. In benign airway obstructions, dilation with a rigid bronchoscope was routinely used. Silicon stents were preferred for managing benign airway obstruction.

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Key words: **central airway stenosis, bronchotherapeutic procedure.**

Significant portions of central airway stenosis patients present with unresectable disease. Using bronchotherapeutic procedures to maintain a patent airway and improve clinical symptoms and quality of life is the well-known armamentarium technique.[1-6] Successful and complicated outcomes from different

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treatment modalities (Nd:YAG laser, cryotherapy, electrocautery, and brachytherapy) previously published depend on the experience and training foundation of surgeons.[1-3] Stenting is beneficial in circumstances of extrinsic compression, persistent tracheobronchial obstruction after laser ablation, dilation, and for chemoradiation therapy.[4] But significant complications exist, and surgeons have tended to maintain a patent airway with relatively conservative endoscopic procedures other than airway stenting.[1,5-7]

Because of the ease in using a flexible bronchoscope in a pulmonary toilet, debridement, and inspection, the interest in flexible bronchoscopic procedures is increasing. According to a report by the American College of Chest Physicians, few surgical residencies or pulmonary fellowships have training opportunities in the use of rigid bronchoscopes, and only 6% of physicians indicated that they performed rigid bronchoscopy.[8] The many advantages of a rigid bronchoscope include ventilation during manipulation, shortened procedure times, greater optical clarity, better instruments for debridement, and the ability to tamponade a bleeding lesion.[1,5-7] We believe that an interventional bronchoscopist should be trained and proficient in using both rigid and flexible bronchoscopes. We report on our preliminary experience in the treatment of central airway obstruction, and emphasize the effectiveness of mechanical coring out, stenting, and dilation.

METHODS

From January to August 2002, 21 patients with central airway obstruction received bronchotherapeutic procedures in Chang Gung Memorial Hospital, Taoyuan. There were 12 males and 9 females with ages ranging from 14 to 87 years. The etiologies includes 4 cases of lung cancer (3 squamous cell carcinomas and 1 small cell carcinoma), 3 cases of esophageal cancer with tracheoesophageal fistula, 6 cases of post-intubation stenosis, 2 cases of laryngotracheal tuberculosis, 1 case of a subglottic web, 1 case of post-anastomotic stenosis, 1 case of laryngotracheal trauma, 1 case of foreign body, and 2 cases of unknown origin. The lesions were all located in the trachea or main bronchus. There were 16 tracheal lesions and involvement of the main or lobar bronchi in 5. All patients in our series had greater than 90% tracheal stenosis.

With the patient in a supine position, general anesthesia was achieved by short-acting narcotics and opioid analgesic agents. A rigid bronchoscope was carefully inserted, and bronchotherapeutic procedures (core out, dilation, and stenting) were engaged depending on the severity and nature of the disease.

When encountering a malignant obstruction, we always thoroughly examined the airway with a rigid bronchoscope and determined the severity as well as the locations of the airway obstruction (estimating the distance from the vocal cords and carina, and the length and diameter of the lesion). Then, we used the beveled tip of the rigid bronchoscope and biopsy forceps to core out the lesion followed by removal of the tumor debris with forceps. A flexible fiberoptic bronchoscope was frequently used through the rigid tube to perform recanalization and to aspirate the purulent discharge of more-distal lobar or distal segmental stenoses.

The dilation procedures were carried out with a rigid bronchoscopic technique sometimes in conjunction with mechanical debridement. According to the location and severity of the obstruction, the choice of a dilator included blunt-tipped Dumon rigid scopes (Novatech; Aubagne, France) or angioplasty balloons.[1]

We implanted stents in circumstances of significant stenosis which persisted after coring out or dilation had failed. These included neoplasms with extrinsic compression of the large airway, obstruction despite coring out or dilation, and tracheobronchial esophageal fistulae. We inserted a Hood silicon stent (Hood Laboratories, Pembroke, MA) using a rigid bronchoscopy technique. We folded and compressed the stent to less than 16 mm and introduced it through the 13-mm Dumon bronchoscope. A Ultraflex stent (Boston Scientific, Natick, MA) was used in patients with malignant obstruction or patients in whom silicon stenting had failed.

We used a Montgomery T-tube in benign stenosis and when resection was deemed unsuitable or inappropriate. We introduced the lower limb of the T-tube through the tracheal stoma and advanced it downwards to the carina. Then, we pushed the upper limb upwards until the entire length of the T-tube was inside the tracheal lumen. The rigid bronchoscope was used to manipulate and confirm the location between the proximal limb and vocal cord. In

circumstances of glottic or supraglottic stenosis, the proximal limb was positioned 0.5 cm above the cord to maintain airway patency; aspiration could be prevented by epiglottic closure.

RESULTS

In total, 26 procedures (4 core outs, 6 dilations, 13 stent placements, 2 biopsies, and 1 foreign body removal) were performed in 21 patients (Table 1). The vast majority of patients showed symptoms improvement after the procedure. There was 1 death and 2 stent-related complications (1 collapse by compression and 1 mucous obstruction) which occurred in this series. Intraoperative bleeding was encountered in 2 patients, and it was successfully controlled by compression of the lesion with the side of the rigid bronchoscope and angioplasty balloon.

Coring out procedure (Fig. 1)

We performed 4 coring out procedures in 4 patients. The first patient had a complication of small-cell lung cancer, and tracheal metastasis caused 90% stenosis of the middle trachea. Etiologies of other 3 patients were squamous cell carcinoma of the lung with invasion of the trachea and main bronchus. Treatment was successful in 3 patients using single coring out procedures. An Ultraflex stent was indicated in 1 patient because of residual stenosis after the coring out procedure. All patients showed clinical improvement after the procedures. Two minor instances of hemorrhage were encountered during the coring out procedure, which were controlled by compression using the rigid bronchoscope and Fogarty balloon.

Dilation (Fig. 2)

Six dilation procedures were used in 6 patients, and only 1 failed case was noted. The airway lumen was opened, and clinical symptoms were immediately improved in the other 5 patients. The etiology of the only failed case was a subglottic web; the airway became restenotic after the procedure and was relieved by laser ablation 1 month later. In these patients, we successfully used the dilation technique as a single procedure in 2 patients with postintubation tracheal stenosis. Dilation was combined with stenting as indicated in 3 instances of tracheal steno-

Table 1. Details of Bronchotherapeutic Procedures in Our Patients

Patient	Age (years)	Diagnosis	Procedure	Procedure / outcome	Duration after procedure
1	69	Lung cancer with tracheal metastasis	Core out	Successful	5 mon
2	61	Lung cancer with tracheal metastasis	Core out	Successful	3 mon
3	62	Lung cancer with left main metastasis	Core out	Successful	1 mon
4	68	Subglottic web	Dilation	Failed	5 mon
5	37	Postintubation stenosis	Dilation	Successful	3 mon
6	74	Postintubation stenosis	Dilation	Successful	3 mon
7	28	Laryngotracheal tuberculosis	Dilation/ Hood & T stent	Successful	5 mon
8	44	Postintubation stenosis	Dilation/ Hood stent	Successful	2 mon
9	14	Postresection stenosis	Dilation/ Hood stent	Successful	1 mon
10	61	Esophageal cancer with T-E fistula	Ultraflex stent	Successful	8 mon
11	70	Lung cancer with right main metastasis	Core out/ Ultraflex stent	Successful	2 mon
12	56	Esophageal cancer with T-E fistula	Ultraflex stent	Successful	8 mon
13	87	Esophageal cancer with T-E fistula	Ultraflex stent	Successful	1 mon
14	49	Postintubation stenosis	T stent	Failed	4 mon
15	49	Postintubation stenosis	T stent	Successful	2 mon
16	21	Trauma with laryngotracheal stenosis	T stent	Successful	1 mon
17	41	Laryngotracheal tuberculosis	T stent	Successful	1 mon
18	76	Postintubation stenosis	T stent	Failed	2 mon
19	43	Endobronchial stenosis	Biopsy	Successful	2 mon
20	58	Endotracheal lesion	Biopsy	Successful	2 mon
21	45	Foreign body	Removal	Successful	2 mon

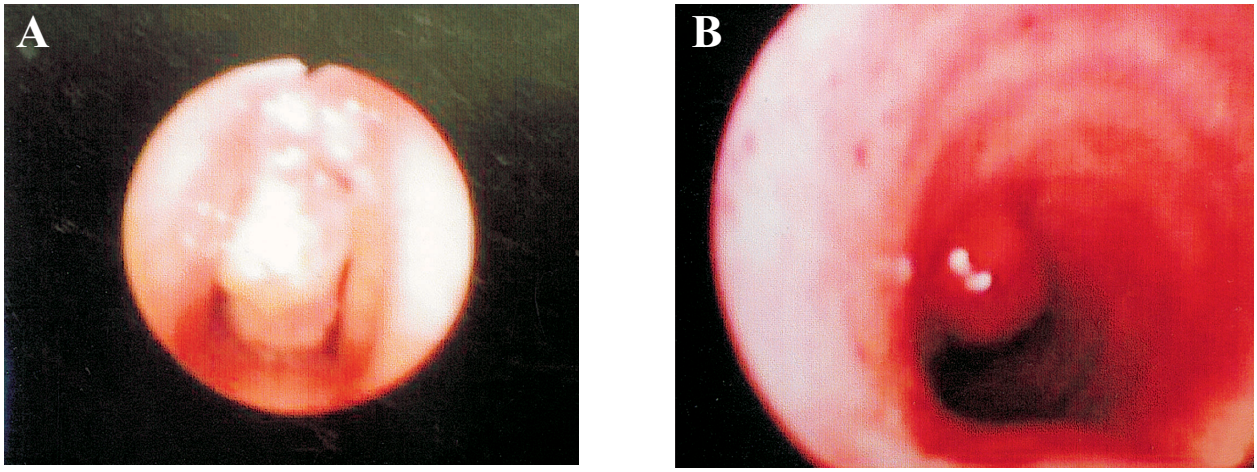

Fig. 1 Coring out procedure. (A) Non-small-cell lung cancer with tracheal metastasis presenting with stridor and respiratory distress. Bronchoscopy revealed an endotracheal tumor with nearly total occlusion of the tracheal lumen. (B) The tracheal tumor was removed, and the lumen was patent after the mechanical coring out procedure.

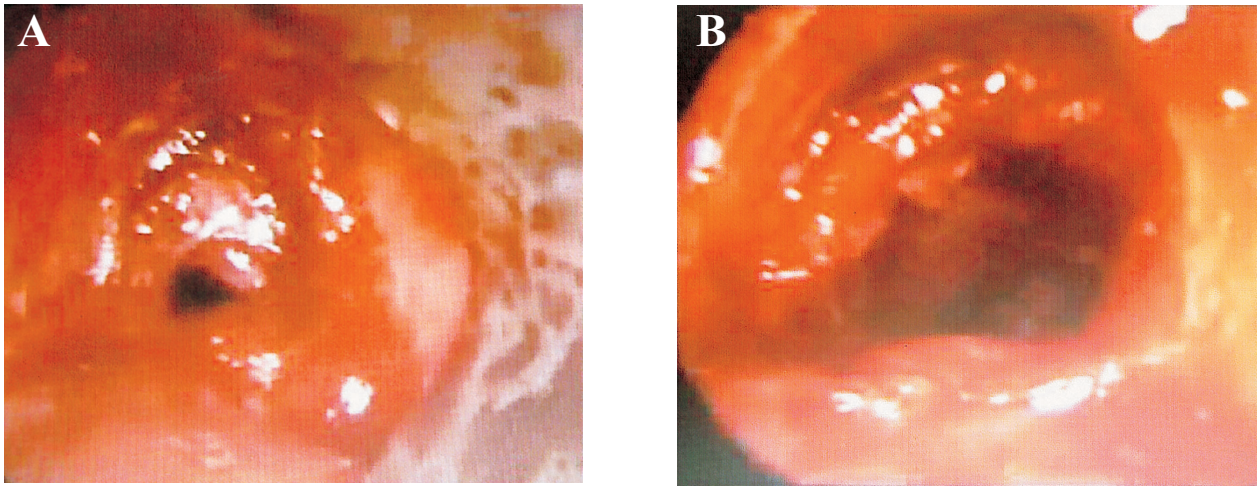

Fig. 2 Dilation procedure. (A) Post-intubation stenosis over the lower third of the trachea. Bronchoscopy revealed 90% stenosis of the tracheal lumen. (B) The airway lumen was widely patent after dilation with a rigid bronchoscope. This patient received an airway stent for recurrent stenosis 2 months after the dilation procedure.

sis caused by laryngotracheal tuberculosis, post-anastomotic stricture, and post-intubation stricture, respectively.

Endotracheal and endobronchial stenting (Figs. 3-5)

Seven stents (4 Ultraflex and 3 Hood stents) were inserted in 7 patients. The underlying diseases included 3 cases of esophageal cancer with tracheal invasion and tracheal esophageal fistula, 1 case of lung cancer with right main bronchus invasion, 1 case of laryngotracheal stenosis after tuberculosis, 1 case of post-intubation stenosis, and 1 case of laryngotracheal stenosis after resection and reconstruction. Good therapeutic or adequate palliative results were achieved in all patients. However, an 86-year-old patient died because of aspiration pneumonia followed by respiratory failure. No complications such

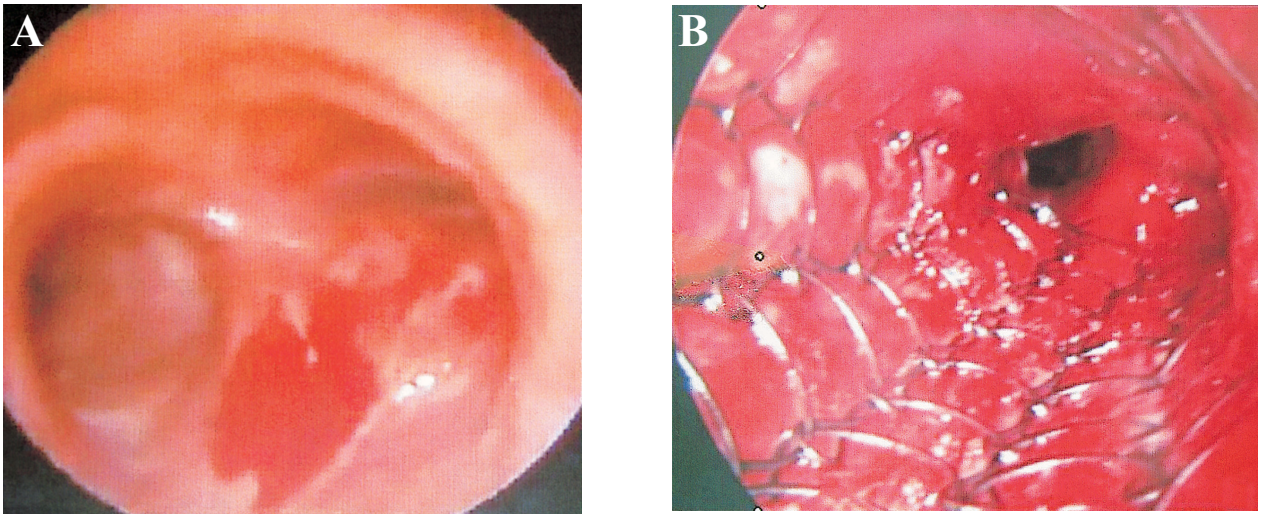

Fig. 3 Stenting procedure. (A) Locally advanced non-small-cell lung cancer with nearly total occlusion of the right main bronchus. (B) A metallic stent was used to maintain airway patency after coring out of the endoluminal tumor with a rigid bronchoscope.

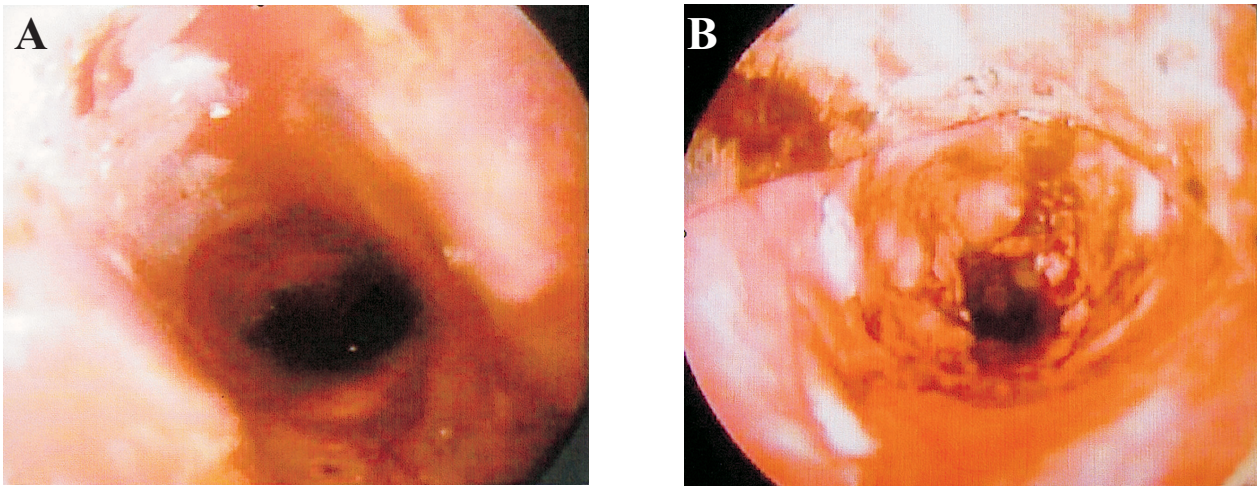

Fig. 4 Stenting procedure. (A) Stricture after resection and reconstruction of laryngotracheal trauma over the cricoid region. (B) A silicon stent was used to maintain airway patency using a rigid bronchoscope over the stricture region.

as stent migration, stent occlusion by sputum, or tumor in-growth were noted. Minor intraoperative bleeding occurred in 1 case of lung cancer with right main bronchial invasion, which was successfully controlled using rigid bronchoscope compression.

Montgomery T-tube

Six patients received T-tube stenting. Four patients were treated successfully. Two procedures failed because of sticky mucoid substance impaction and severe stenosis of the supraglottic region, for which a tracheotomy tube was indicated. All successfully treated patients showed improvement in respiratory symptoms and function of phonation. Two arytenoid split procedures were required to implant the T-tube because of severe stenosis at the glottis level. One patient with laryngotracheal tuberculosis had a complication of long-segment stenosis from the subglottic region to the lower third of the trachea. The stenosis persisted after multiple dilation

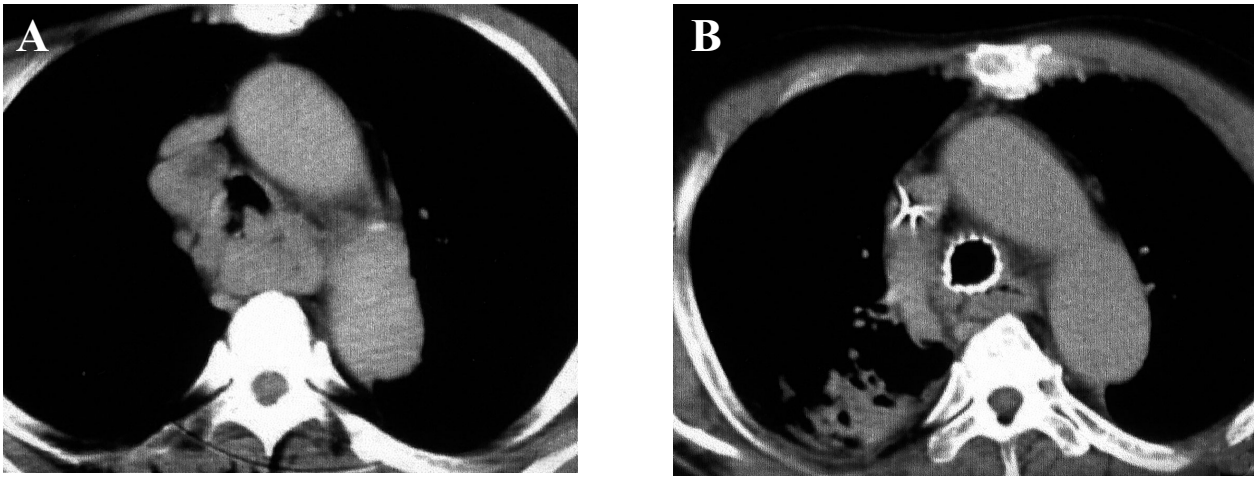

Fig. 5 Stenting procedure. (A) Esophageal cancer with airway invasion and obstruction presented with cough and respiratory distress. (B) A metallic stent was used to maintain airway patency, and significant improvements in respiratory symptoms were achieved.

and tracheotomy procedures; we thus incorporated a Hood stent into a Montgomery T-tube to maintain a patent airway, and the patient experienced no problems during her second trimester of pregnancy.

DISCUSSION

Bronchotherapeutic procedures include laser, brachytherapy, dilation, stenting, photodynamic therapy, electrocautery, cryotherapy, and bronchoscopic resection of airway tumors. Rigid or flexible bronchoscopes can be used to apply these procedures. In general, laser therapy, electrocautery, cryotherapy, and photodynamic therapy can be performed using either a rigid or flexible bronchoscopy.[1-3,7,9-15] Dilation of malignant airway stenosis can be achieved using either rigid bronchoscope bougination or balloon dilation via the working canal of the flexible bronchoscope.[16,17] Placement of the brachytherapy catheter containing the radioactive source is usually done by direct visualization using a flexible bronchoscope.[18-21] A rigid bronchoscope is essential for the insertion, manipulation, and removal of silicone stents.[1-3] However, metal stents can be inserted with the aid of flexible bronchoscope and/or fluoroscopic guidance.[10,11] A flexible bronchoscope is familiar to many pulmonologists who have not trained with a rigid bronchoscope, while a rigid bronchoscope has the advantage of ventilating patients under general anesthesia during an operation.[9-11] In our series, we felt comfortable using the rigid bronchoscope technique, and we used it to perform all procedures except in the patient with the subglottic web.

Debulking of a tumor with rigid forceps was first described and defined as a core out procedure by Grillo and Mathisen.[7] They reported 90% improvement in airway patency in 56 patients. The Nd:YAG laser has shown good performance in both benign and malignant obstruction. The benefits of vaporizing a central airway obstruction to achieve the goals of a patent airway, relief of dyspnea symptoms, resolution of postobstructive pneumonia, and improvement in the quality of life have been reported from multiple series.[12,13] However, complications of hemorrhage and death existed.[2,14]

Wood et al.[5] described the identical indications of laser vaporization and mechanical coring out. A laser has the advantages of engaging the stenosis over the right upper lobe orifices under topical anesthesia. Also, a laser is hemostatic, and many physicians prefer it because of concerns about bleeding during coring out procedures. However, a laser can produce such complications as potential airway fire, skin burns, perforations, and bronchopulmonary artery fistulae.[12,13,15,22] Rigid bronchoscopy provides

ventilation and safe circumstances for airway control during therapeutic procedures. Coring-out procedures are technically simple, quick, and reliable in establishing an airway, and they require no equipment beyond the standard rigid bronchoscope and instruments. A major limitation includes producing lesions with a dominant extrinsic component. We feel that laser resection provides few benefits over mechanical coring out procedures. It requires more time to achieve a patent airway and adds significant complexity in the setup of the equipment.

Good results following treatment of atherosclerotic arteries with balloon angioplasty and various experiences with airway stenosis treated with dilation have been reported. These include successful outcomes using a Fogarty embolectomy catheter with a flexible bronchoscope for dilation of airway stenosis with sarcoidosis, dilation of stenosis in a post-anastomosis stricture in transplant patients, and good results in cases of benign stricture such as fibrosing mediastinitis.[15,16] However, bronchospasm, atelectasis, airway laceration, and chest pain during balloon inflation were reported.[17] Dilation procedures offer immediate symptom relief and can be used in conjunction with a Nd:YAG laser, cryotherapy, and stent placement. They also can be used to establish a patent airway in circumstances when laser recanalization is contraindicated or considered too dangerous.[16,17] Twenty-eight percent of patients in our series received a dilation procedure with an 83% success rate and no complications. We feel that using different sizes of dilator based on the severity of stenosis is a safe and efficient procedure for relieving airway stenosis.

Brachytherapy is effective in palliating complications caused by malignant endobronchial tumors. It provides symptomatic relief of hemoptysis, dyspnea, cough, atelectasis, and post-obstructive pneumonia. It has curative potential in early-stage endobronchial tumors.[18,19] It can be used as single or adjuvant therapy to a Nd:YAG laser, coring out, and stenting procedures.[18-21] However, a significant rate of fistula formation, radiation toxicities, massive hemoptysis, bronchial stenosis, soft tissue necrosis, and bronchial fistulae have been reported.[19,20,23]

Stenting is indicated in circumstances of malignant neoplasms with extrinsic compression of the airway, persistent obstruction after laser ablation, and dilation, and in patients undergoing external beam radiation or chemotherapy.[1-3,5,6] There are 3 types of stents. Silicone stents are the most widely used airway stents and have the benefits of being easily molded, well tolerated, and relatively inexpensive. They can achieve a significant migration rate with obstruction by secretions and granulation tissue.[21] Metal stents are easily placed and rarely migrate after insertion. However, they are more expensive, difficult to remove, and can cause tissue ingrowth.[24] Hybrid stents are made of metal struts covered with a silicone membrane, and have the benefits of being resistant to external compression and limiting tumor and granulation tissue ingrowth. The characteristics of high cost and difficulty in repositioning and removal impede the use of these devices.[25] In our series, stenting was used in 33% of central airway obstructions. We used silicone stents in 43% and metal stents in 57% of cases. We believe that revision or remodeling of stents after placement is unavoidable, and we reserve metal stents for cases of malignant obstruction or extrinsic compression after failed silicon stenting.

Regarding the therapeutic modality of malignant esophageal fistulae, Christie and associates[26] reported immediate improvement of dysphagia in 85% of patients using expandable esophageal metal stents. Takamori[27] reported immediate relief of respiratory symptoms in 8 of 12 patients after inserting a tracheal stent. Nomori[28] illustrated improvement of airway and esophageal symptoms after double (esophageal and intratracheal) stenting; however, 5 of the 8 patients experienced tissue necrosis and worsening of esophageal-airway fistulas. In our patient with malignant stenosis over both the esophageal and tracheobronchial trees, the covered stent was inserted into the tracheobronchus to relieve the respiratory symptoms. Feeding jejunostomy was performed to provide adequate nutritional support. We did not introduce a double stent in order to avoid operative costs and avoid catastrophic complications of possible future fistula formation.

The Montgomery T-tube was introduced in 1965 and is widely used for palliation of stenosis over supraglottic, glottic, subglottic, and tracheal lesions untreatable by surgical procedures. It has the benefits of providing a functional larynx, preserving the voice, and maintaining a moistened airway. The T-tube can be introduced by direct insertion via tracheal stoma or with a rigid bronchoscopic technique.

In circumstances of glottic or supraglottic stenosis, the proximal limb of the T-tube was placed 0.5 cm above the vocal cord; and aspiration was prevented by approximation of the false cords and deflection of the epiglottis.[29] In our experience, 2 patients with the tube resting above the vocal cord had no aspiration symptoms, and their phonation function significantly improved.

Complications of laser ablation include anoxia, hypercarbia, fire, fatal hemorrhage, pneumothorax, pneumomediastinum, and T-E fistula.[14,30] Insertion of a brachytherapy catheter may be accompanied by minor complications (minor pneumothorax, bleeding, infection, cough, catheter displacement, and bronchospasm) and serious complications (massive hemoptysis and fistula formation).[19,20,23] Complications of stenting include hemorrhage, migration, and fibrin's obstruction.[4,21,24,25] In our series, we had 1 mortality, 2 (8%) stent-related complications, and 2 (8%) instances of minimal intraoperative bleeding, both of which were successfully controlled.

The safety and comfort of the procedure can be achieved by good communication and coordination between the operative surgeon and anesthesiologist. Among various techniques for palliative central airway stenosis, the mechanical coring out procedure was the most immediately reliable strategy for endoluminal tumors.[5,6] Laser vaporization, dilation, cryotherapy, and photodynamic therapy provide successful airway palliation.[5,6] Stenting provides immediate treatment for unresectable extrinsic airway compression and provides prompt stabilization of a threatened airway.[4-6] Potential complications can be diminished by implementing safety procedures. A small degree of hemorrhage can be controlled by compression with the tip of the rigid bronchoscope, epinephrine suspension, or thrombin-soaked gauze.

We present our endoscopic experience in central tracheobronchial obstruction. After completely assessing the anatomy and character of the airway obstruction, we differentiated the causes of disease into intrinsic or extrinsic compression. We resected the endobronchial tumor (intrinsic) with the tip of a rigid bronchoscope and evaluated the stenosis severity, and silicon stents were inserted if indicated. In extrinsic lesions, stenting was always suggested after the dilation procedure. We used metallic stents in cases involving difficult anatomy and after failed silicon stent placement. We believe that the ability to use a rigid bronchoscope in bronchotherapeutic procedures depends on the experience and skill which can be obtained by frequent use and meticulous training in central airway stenosis patients.

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氣管介入性治療對中央氣道狹窄之初期經驗

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背 景： 中心氣道狹窄的治療對醫護人員是極具挑戰性的。本文將報告我們過去8個月的治療經驗。

方 法： 自西元2002年1月至8月，共有21位患者接受26項的氣管鏡手術，包括4次腫瘤切除，6次狹窄撐開，13次支架置入，2次組織切片檢查，1次異物取除，而這些手術都是單獨或使用硬式氣管鏡輔助下所完成。疾病的原因包括4例肺癌，3例食道癌合併氣道氣管廔管，6例氣管插管合併症，1例喉部外傷，1例聲門環狀下蹼，1例異物取除，2例不明原因氣道狹窄。

結 果： 17位患者藉由氣管介入性治療，臨床症狀明顯改善，同時兩位患者有術後併發症。一位87歲的食道癌患者，於術後第5天因肺炎及呼吸衰竭而死亡。兩位聲門嚴重狹窄接受T型支架植入的患者，因大量痰液阻塞及支架的壓迫，而必須將支架取除。另外，兩位接受腫瘤切除的患者，因術中少量出血使用氣管鏡進行壓迫止血，而得到良好的控制。在我們的經驗中，沒有因治療而導致氣管撕裂傷的病例。

結 論： 對於惡性腫瘤造成的氣道狹窄，我們會使用硬式氣管鏡的尖端將腫瘤切除，再依狹窄殘餘的嚴重程度考慮是否植入金屬或矽製氣道支架。對於良性的氣道狹窄，常使用硬式氣管鏡先將狹窄撐開，而支架的選擇，較喜好矽製的支架。

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關鍵字： 中央氣道狹窄，氣管介入性治療。

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