Guidelines

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Interventional Bronchoscopy for the Treatment of Malignant Central Airway Stenosis: An Expert Recommendation for China

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Keywords
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Abstract
Malignant central airway stenosis refers to airway stenosis caused by primary or metastatic malignant tumors which may lead to different levels of dyspnea or asphyxia in patients. With the rapid development of interventional pulmonology, therapeutic bronchoscopy has become one of the main methods for the diagnosis and treatment of malignant central airway stenosis. However, the level of diagnosis and treatment of respiratory intervention techniques in China is uneven at present, the treatment methods are not uniform, the treatment effects vary greatly, and some treatments even lead to serious complications. The interventional treatment technology for malignant central airway stenosis in China needs to be standardized. Therefore, the relevant experts of the Beijing Health Promotion Association Respiratory and Oncology Intervention and Treatment Alliance have formulated this consensus after several rounds of full discussion.

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Malignant central airway stenosis refers to airway stenosis caused by primary or metastatic malignant tumors of trachea, carina, left and right main bronchus, right upper lobe bronchus, intermediate bronchus, left upper lobe bronchus, and left lower lobe bronchus, which may lead to different levels of dyspnea or asphyxia in patients [1]. With the rapid development of interventional pulmonology, therapeutic bronchoscopy has become one of the main methods for the diagnosis and treatment of malignant central airway stenosis [2]. However, at present, the level of diagnosis and treatment of respiratory intervention techniques in China is uneven, the treatment methods are not uniform, the treatment effects vary greatly, and some treatments even lead to serious complications. The interventional treatment technology for malignant central airway stenosis in China needs to be standardized. Therefore, the relevant experts of the Beijing Health Promotion Association Respiratory and Oncology Intervention and Treatment Alliance have formulated this consensus after several rounds of full discussion.

The Cause of Malignant Central Airway Stenosis

Common diseases of malignant central airway stenosis include primary malignant tumors of the trachea and metastatic malignant tumors. Primary airway tumors are squamous cell carcinoma, adenoid cystic carcinoma, carcinoid, mucoepidermoid carcinoma, and adenocarcinoma. The metastatic tumors may derive from almost any part of the body, and the distal airway lesions involve the proximal or esophageal, mediastinal, thyroid, thymus, and other tumors involving the trachea or the compressed trachea. The most easily metastatic tumors to the central airway include upper respiratory tract tumors, digestive tract tumors, breast cancer, renal cell carcinoma, metastatic melanoma, and lymphoma [3, 4].

Classification and Grading of Malignant Central Airway Stenosis

Generally, the central airway stenosis is divided into four categories according to whether the tumor is simply located in the lumen, outside the lumen, lumen wall, and mixed type, as shown in Figure 1. They are: (1) intraluminal type – the tumor is confined to the lumen. It is called endogenous or intraluminal; (2) extraluminal type – the tumors are outside the lumen without the intraluminal part, and the tracheal stenosis is caused by the growth and compression of extraluminal tumors, and there is no intraluminal tissue and tube wall damage, it is called external pressure type, i.e. extraluminal type; (3) tracheal wall type – the tumor grows along the wall of the tracheal with wide base and thick tracheal wall, which can cause lumen stenosis; (4) mixed type – the tumor has intraluminal growth and also tracheal wall and extraluminal involvement. The mixed type often originates from tissues adjacent to the airways, and with the growth of tumor tissue eventually invades the airway walls and the lumen [5].

The severity of malignant airway stenosis is usually graded according to the degree of stenosis (%) of the tracheal diameter, and the degree of stenosis of the tracheal diameter = narrow diameter/normal diameter × 100%. The severity of the stenosis is described by the numerical code 1–5 (in 5 grades), and the severity of the central airway stenosis is graded (Table 1).

Partition and Localization of Malignant Central Airway Stenosis

Big data analysis revealed that tumors had different predilection sites in different regions of the central airway. Wang [6] divided the malignant central airway stenosis into eight divisions according to the anatomical location of stenosis (Table 2).

The patients with grade 1 stenosis are considered to be mildly stenotic and may have no symptoms or only mild cough; grades 2 and 3 are moderately stenotic and may have symptoms such as cough and shortness of breath; grades 4 and 5 are severe malignant central airway stenosis, and severe cough and dyspnea, three depression signs, cyanosis, or even asphyxia death may occur [7]. The degree of dyspnea depends mainly on the diameter of the narrow airway. In general, when the tumor is blocked or compressed, and the degree of tracheal stenosis is >50%, the patient may have obvious dyspnea. Normally, the average diameter of the airway and left and right main bronchi is 12–18, 8–14, and 10–16 mm, respectively; when the tracheal diameter is <8 mm, the patient will have exertional dyspnea; when resting dyspnea occurs, the tracheal diameter is <5 mm. The left and right main bronchi or the middle segment of the bronchus was partially narrow or even completely blocked, but due to the compensatory effect of the other side of the lung, the patient's dyspnea severity was different. Other common signs and symptoms include cough, wheezing and stridor, as well as recurrent or persistent obstructive pneumonia. Wheezing often indicates that the lesion is involved at the tracheal or larynx

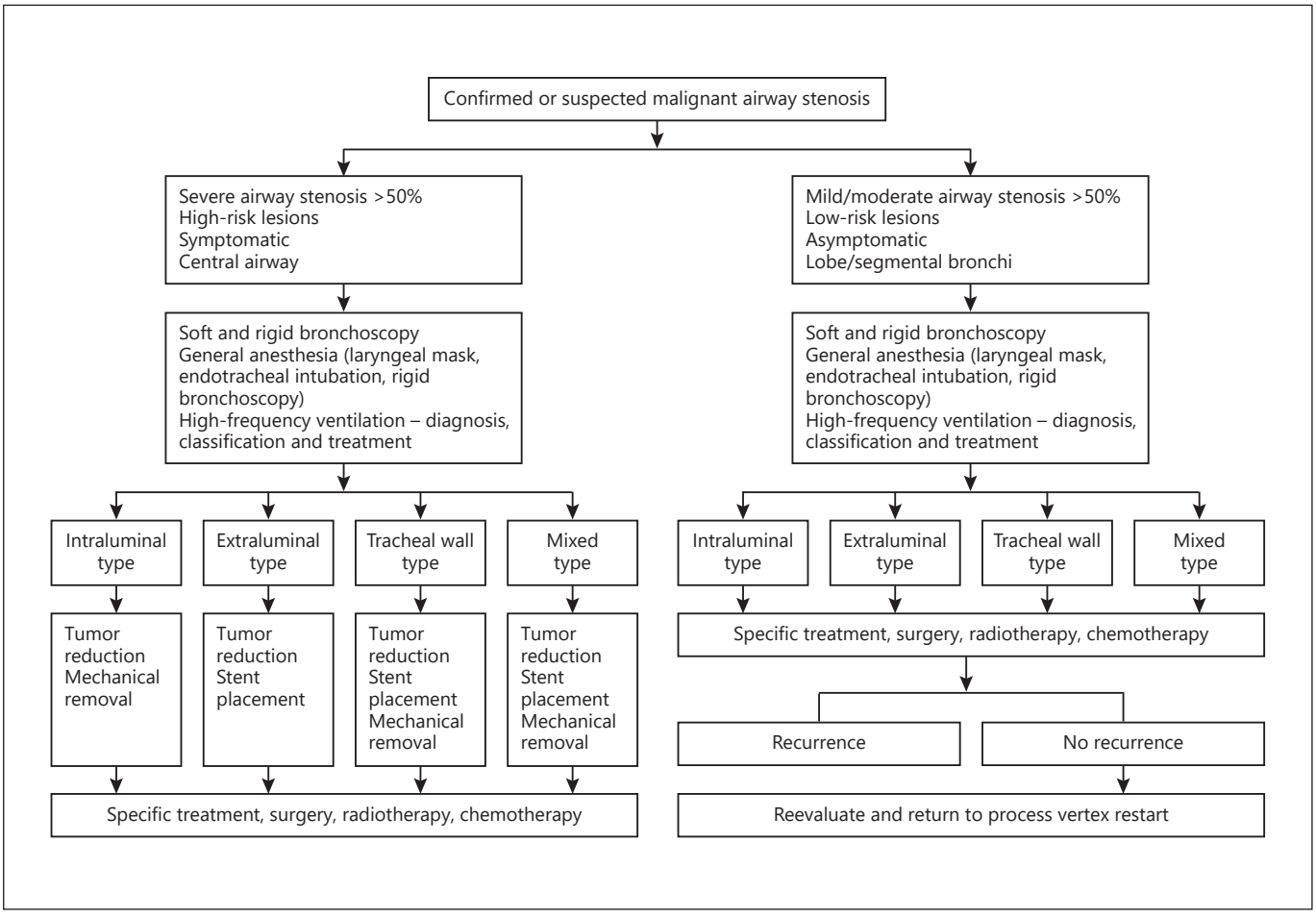

Fig. 1. Flow chart of diagnosis and treatment of malignant central airway stenosis.

Table 1. Grading of severity of central airway stenosis

Grading	Severity of central airway stenosis, %
1	≤
2	26–50
3	51–75
4	76–90
5	91–100

Table 2. Location of airway lesions

Segment	Location of airway lesions
I	1/3 upper segment of the main trachea
II	1/3 middle segment of the main trachea
III	1/3 lower segment of the main trachea
IV	carina
V	right main bronchus
VI	right middle segment bronchus
VII	nearly 1/2 segment of the left main bronchus
VIII	far 1/2 segment of the left main bronchus

level, while stridor suggests that the airway obstruction may be local or distal to the carina.

The tumors vary in different areas. Generally speaking, the most common tumors in region I are squamous cell carcinoma and thyroid cancer, while those in regions II and III are mainly squamous cell carcinoma, adenoid cystic carcinoma, and esophageal cancer. The most common tumors in regions IV and V are squamous cell carcinoma and adenoid cystic carcinoma, and those in region VI are squamous cell carcinoma and mucoepider-

moid carcinoma. The tumors in region VII are usually squamous cell carcinoma, esophageal cancer, adenoid cystic carcinoma, and mucoepidermoid carcinoma, while tumors in region VIII are adenocarcinoma, esophageal cancer, and mucoepidermoid carcinoma.

Diagnosis of Malignant Central Airway Stenosis

Malignant central airway stenosis is easy to be misdiagnosed or missed because there are nonspecific clinical signs and symptoms. Therefore, the diagnosis of suspected malignant airway stenosis should be highly valued, while excluding other diseases that cause wheezing, especially asthma, tuberculosis or other benign airway stenosis. Detailed history collection, physical examination, imaging examination, bronchoscopy, pulmonary function test, and arterial blood gas analysis should be performed during diagnosis. This information is important for selecting interventional procedures, anesthesia methods, predicting possible complications, and evaluating prognosis. The flow chart of malignant central airway stenosis is shown in Figure 1.

1 Medical history collection. Patients with malignant central airway stenosis may present with irritable dry cough and progressive dyspnea, sometimes with blood in sputum or hemoptysis. Patients with these symptoms, especially those with a history of malignancies, should be highly considered for airway invasion or metastasis.
2 Physical examination. Dyspnea is the most important sign of malignant central airway stenosis, and it can be manifested as inspiratory, expiratory, or mixed dyspnea according to the location and size and growth pattern of the lesion. In severe cases, there may be three depression signs and cyanosis. Auscultation of the lungs can be heard with rhonchi or wheezing. Sometimes snoring can be heard in cases of subglottic or tracheal stenosis. Localized wheezing can be heard in patients with left and right main bronchus or middle segment bronchoconstriction, and high-pitched wheezing and local atelectasis can present in patients when inhaling.
3 Chest imaging examination. The value of chest X-rays for the diagnosis of malignant airway stenosis is limited, and only a few patients can present tracheal or main bronchial lesions or atelectasis. In addition, indirect signs can determine the location and extent of the lesion. Tracheal and bronchial tomography can also be helpful in the diagnosis of stenosis [8]. Chest CT is an important method for diagnosing malignant central airway stenosis; in particular, multislice spiral CT can reconstruct three-dimensional images, establish virtual trachea and bronchial images, and perform 3D printing; it can easily figure out the location and severity of the lesion, the depth of invasion, the relationship with peripheral vessels, and provide diagnostic basis for the patency of the distal airway and the consolidation of the distal lung tissue and the presence of lesions [9, 10]. Magnetic resonance imaging can determine the type and extent of bronchial stenosis; especially the judgment of bronchial extravasation stenosis is more accurate, and it has an important guiding role in the pursuit of reasonable interventional therapy [11]. However, it should be reminded that although chest CT is the primary method for diagnosing malignant airway stenosis, it has a limited ability to detect mild airway stenosis, and often underestimates the length of airway stenosis compared with bronchoscopy [12].
4 Bronchoscopy. Bronchoscopy is the gold standard for the diagnosis of malignant central airway stenosis [13]. All the patients suspected to have malignant central airway stenosis diagnosed by medical history collection, physical examination, and imaging examination, in the absence of bronchoscopy contraindications, depending on the location, type, severity, and patient tolerance of the airway stenosis, should undergo bronchoscopy under the safety protection measures, so that the location, size of the lesion, and extent and severity of the stenosis can be directly observed, and qualitative diagnosis can be made by suction, lavage, and biopsy [14]. The current diagnosis is mainly completed by histopathological diagnosis of bronchoscopy biopsy. In addition, EBUS-guided transbronchial needle aspiration biopsy can be used for qualitative diagnosis of extraluminal stenosis, and can also be used to identify the tracheal cartilage le-

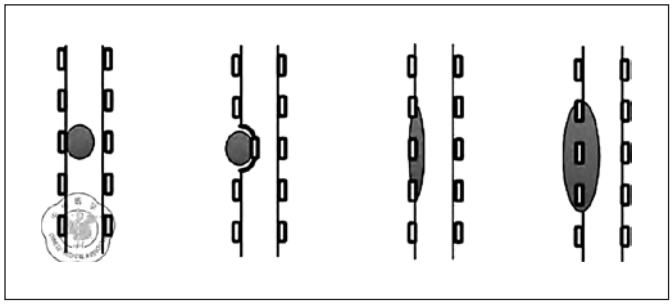

Fig. 2. The types of malignant central airway stenosis.

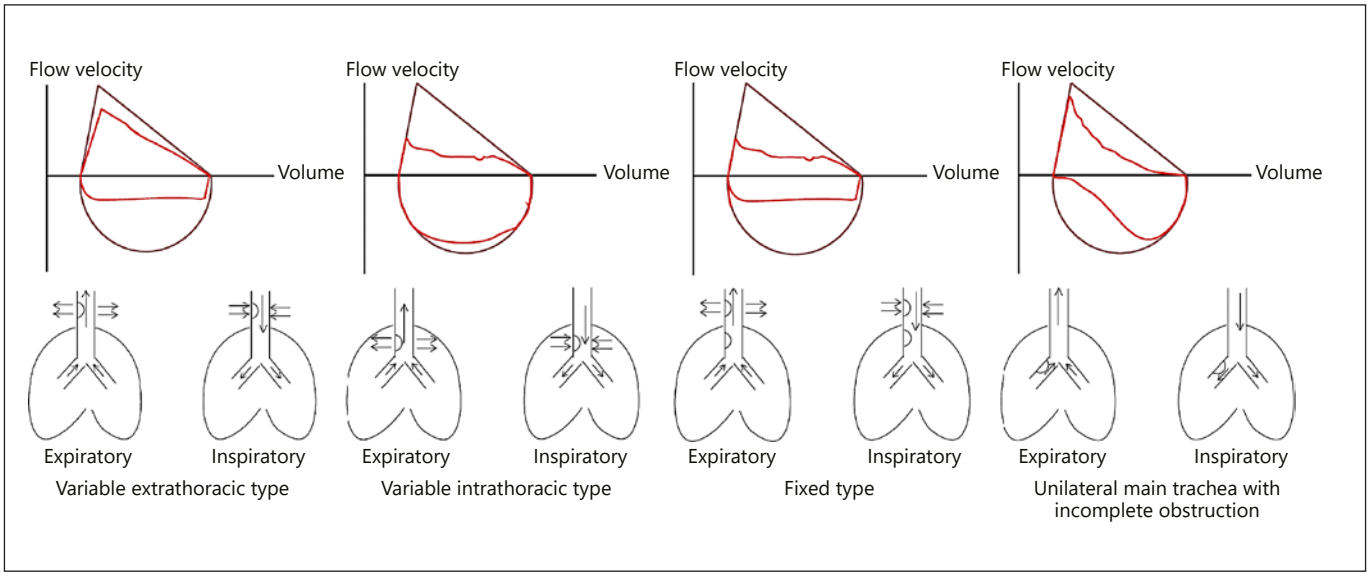

Fig. 3. Upper airway obstruction flow-volume curve change diagram.

sions and tracheal cartilage invasion [15, 16]. Virtual bronchoscopy can determine the function of the distal bronchus and lung tissue. The types of malignant central airway stenosis are shown in Figure 2.

5 Pulmonary function tests. Pulmonary function tests include spirometry and flow volume line (FVL) analysis. Respiratory failure can be induced by spirometry and may not be measured in patients with severe airway stenosis. When the airway stenosis diameter is ≤6 mm, the forced expiratory volume in 1 s (FEV1) test decreases significantly. Therefore, the change of FEV may be earlier than that of FEV1. Compared with FEV1, peak expiratory flow (PEF) and maximal voluntary ventilation (MVV) are more sensitive to the diagnosis of airway stenosis. In spirometry, airway stenosis should be considered if the PEF decline is significantly lower than the decline in FEV1. Airway stenosis is common when the ratio of MVV to FEV1 is <25%. Airway stenosis should also be considered when MVV falls and FEV1 is normal. However, these airway stenoses are relatively mild, and severe airway stenosis is not available to perform spirometry. FVL can not only distinguish between intrathoracic and extrathoracic central airway stenosis but also fixation and variable stenosis. FVL helps to assess the basic condition of the lungs, determine the safety of interventional procedures, and decide on the anesthesia method and the corresponding airway management measures that need to be taken during surgery [17].

The morphological features of the pulmonary function F-V curve are useful for the diagnosis of airway obstruction, the severity of the lesion, the evaluation of the therapeutic effect, and the development of relevant treatment options. Because the intrathoracic and extrathoracic pressure is affected by different respiratory phases, if the stenosis is a variable intrathoracic airway obstruction, the expiratory airflow is limited, and the FV curve shows obvious plateau-like changes in the expiratory phase, whereas the inspiratory phase is generally normal, and the lesions are mostly confined to the chest entrance (such as airway tumors, bronchial tuberculosis, airway foreign bodies, etc.); if the stenosis is a variable extrathoracic airway obstruction, inspiratory airflow is limited, FV curve shows obvious plateau-like changes in the inspiratory phase, expiratory gas is generally normal, and lesions are generally confined to the chest outside of the entrance (such as laryngeal cancer, vocal cord dysfunction, laryngeal edema, glottic stenosis, esophageal cancer, goiter cancer, etc.); The fixed airway obstruction FV curve shows a biphasic plateau-like change, suggesting that the lesions were extensive and more severe. The "double discs shadow" like FVL can be seen in incomplete unilateral main bronchial obstruction (Fig. 3). Therefore, preoperative pulmonary function tests can help predict the location of airway stenosis. It can also be measured by impulse oscillometry, and the position and degree of stenosis can be judged according to the corresponding indicators.

6 Arterial blood gas analysis. Arterial blood gas analysis is used to determine the pulmonary ventilation and gas exchange function, the severity of hypoxia, and the acid-base imbalance type. However, it cannot be used to judge the severity of airway stenosis, because even for severe airway stenosis, patients present with extreme dyspnea, but blood gas analysis, especially PaO_2 may be normal. Therefore, for patients with no history of chronic respiratory diseases and normal lung function, even if $PaCO_2$ is slightly or moderately elevated, great attention should be paid and urgent treatment should be given. Intraoperative and postoperative blood oxygen saturation and PaO_2 decline should be identified, evaluated, and dealt with actively. In conclusion, arterial blood gas analysis is an important indicator of functional evaluation in preoperative, intraoperative and postoperative interventional therapy for patients undergoing endoscopy. The dynamic monitoring of arterial blood gas plays an important role in the surgical safety assessment.

Treatment of Malignant Central Airway Stenosis

The malignant central airway stenosis is asymptomatic or mild in the early stage, and can often be neglected. Once the dyspnea has occurred, the stenosis will aggravate quickly, which will bring certain risks and difficulties during the treatment. Treatment for malignant airway stenosis includes surgical treatment and interventional treatment guided by bronchoscopy.

1 Traditional surgical treatment methods: Sleeve resection, bronchotomy, and airway reconstruction are the main methods for resection of tracheal carcinoma. For airway stenosis caused by compression of the trachea such as thyroid cancer, thymic malignancy, mediastinal malignant tumor, etc., the primary tumor should be surgically removed. However, because of the large trauma, high risk of surgical resection, and anatomical limitations on the lesions in some patients, such as the extensive lesion areas (more than two areas), full-thickness invasion of the tracheal wall and mixed stenosis, metastatic cancer, etc., or poor basic conditions of patients, the surgical operation indications for most malignant airway stenosis are limited, and surgery cannot deal with the most malignant airway stenoses. In some patients, postoperative anastomotic stoma can also cause scar hyperplasia and cause restenosis.
2 Bronchoscopic interventional therapy. With the rapid development and wide application of interventional respiratory disease treatment technology in China, more and more malignant airway stenosis patients benefit from appropriate interventional therapy. At present, bronchoscopy intervention of malignant central airway stenosis by bronchoscope is mainly through thermal ablation (laser, electrotome, argon knife, etc.), cold ablation (freeze-thaw or freeze-cut), mechanical resection (rigid endoscopy), and airway dilatation (stent placement or rigid endoscopy dilatation). These techniques are designed to quickly achieve unobstructed airways, improve ventilation, and prevent asphyxia [18–20].

(i) Ablation technology. By heat or cold ablation technology, the tumor tissues can be necrosed, carbonized, and even vaporized to achieve the purpose of eliminating the lesion. It mainly includes thermal ablation and cold ablation [21]. Thermal ablation refers to the use of microwave, laser, high-frequency electrotome and argon plasma coagulation to heat tissue, or induce necrosis and vaporization of tissue, thereby reducing the volume of tumor tissue [22–24]. Cold ablation refers to the use of freeze-thaw or freeze-cut methods to destroy, necrose, or cut tumor lesion.

(ii) Mechanic resection. It can rapidly relieve stenosis by removing all or part of the tumor through the front end of rigid bronchoscope or light microscope, or directly clamp the tumor through large biopsy forceps under a rigid bronchoscope to achieve smooth airway rapidly [25].

(iii) Airway dilatation. There are three methods to dilate the airway, including high-pressure balloon dilatation, mechanical dilatation by rigid bronchoscope, and stent implantation [26, 27].

High-pressure balloon dilatation is mainly used for benign airway stenosis, but it can be used in patients with partial malignant airway stenosis, especially those with airway external compression and damaged airway cartilage [28]. The existing balloon is designed specifically for airway dilatation, but various types of blood vessels and esophageal balloons can also be used for dilation. After placing the balloon in the stenosis airway, the balloon can be extended to the preset diameter by saline infusion, and then last for 30–60 s. Normally, this procedure will be repeated 3–5 times. When dilating the airway, the patient is asphyxiated during the whole balloon filling period, and it is better to carry it out under general anesthesia. Excessive filling of the balloon can cause tearing of the airway and should be taken seriously. The balloon can also be used to rapidly dilate the stent when the stent is poorly opened.

The rigid bronchoscope itself can be used for airway dilation, especially for the proximal airway. In general anesthesia combined with high-frequency ventilation to dilate, when the rigid mirror passes through the obstruction area, it is better to retain it for several minutes for full expansion, which has the advantage of allowing the patient to ventilate throughout the procedure. In addition, during the operation, the rigid bronchoscope can help to eradicate the tumor tissues in the lumen [28]. The operation must be kept on the same level to prevent the mirror body from deviating from the direction and causing airway perforation.

Stent placement can dilate the airway continuously, and it is often used when high-pressure balloon dilatation, rigid endoscopy dilatation, and clearance of intraluminal lesions cannot keep the airway open. How to choose the most appropriate stent depends on the surgeon's experience, the cost, the structure of the lesion, and the patient's condition. The eight-zone method and location of malignant central airway stenosis are helpful for choosing the suitable airway stent. Straight stents are suitable for lesions in zones I, VI, and VIII, and bifurcated stents (L or Y) are suitable for zones II, III, IV, V, and VII near the carina. Silicone stents require general anesthesia and are placed under a rigid microscope. The silicone stent is soft, the support is insufficient, and it is easy to shift. The curved lesion is not suitable for placement because it may protrude into the airway and cause obstruction [29]. Therefore, it is best to use a suitable metal stent for patients with malignant airway stenosis. The characteristics of silicone stents and metal stents are shown in Table 3.

Table 3. Comparison of silicone and metal stents

Silicone stents	Metal stents
Benign/malignant	Mainly used for malignant tumors; in benign tumors, they should be used with caution
Can be removed	The bare stent is difficult to remove, and the stent-graft is easy to remove
Only suitable for rigid bronchoscopy	Flexible bronchoscope or rigid bronchoscope
Displacement	The bare stent is less displaced, and the straight stent is easily displaced
Impediment adjacent to the bronchi	Only the stent graft will impede adjacent bronchial tubes
Granulation tissue	Granulation tissue is relatively small
Secretion	Less secretion
Soft, not easy to adapt to airway changes	Expandable, able to adapt to airway changes

Standards and Principles of Bronchoscopic Interventional Therapy for Malignant Central Airway Stenosis

Bronchoscopic interventional therapy for malignant central airway stenosis is a complex technique. Standards and principles should be strictly implemented in the following six aspects to ensure the smooth operation of the intervention and patient safety.

1 Principles for patient selection. Bronchoscopic interventional therapy is optional for patients with central airway stenosis caused by primary malignancy or metastatic malignancy that cannot be surgically treated or refused surgery. Before the therapy, the function of the distal tracheal, bronchus, and lung tissue should be evaluated, and if the function of distal bronchus and lung tissue cannot recover and is not expected to recover after airway opening, interventional therapy should be abandoned [30].
2 Principles for selecting emergency or elective surgery. Determine emergency or elective surgery based on the location and extent of the stenosis and the degree of dyspnea. Emergency surgery should be operated on the patients with severe dyspnea which endanger their lives at any time, such as severe stenosis of the trachea, carina, left and right main bronchus, one-sided bronchoconstriction, contralateral lung resection or obvious pulmonary dysfunction or atelectasis. And for other patients with mild or moderate stenosis, whose lives are not at risk in the short term, elective operation may be the best choice [31].
3 Principles for choosing anesthesia and ventilation methods.

(i) General anesthesia. General anesthesia refers to temporary inhibition of the central nervous system though intravenous or intramuscular injection of anesthetics. Its clinical manifestations include loss of consciousness, loss of generalized pain, forgetting, reflex inhibition, and skeletal muscle relaxation. The degree of inhibition of the central nervous system is related to the concentration of the drug in the blood and can be controlled and regulated. This inhibition is completely reversible, and the patient's consciousness and various reflexes gradually recover when the drug is metabolized or excreted from the body. General intravenous anesthesia is a widely used anesthesia method in bronchoscopic in-

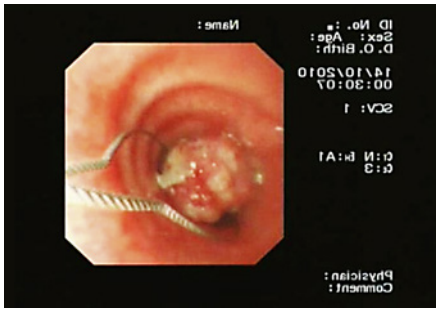

Fig. 4. Spherical neoplasm in trachea, with pedicles, moving up and down with respiration.

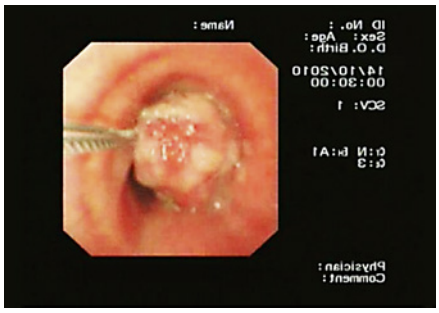

Fig. 5. Neoplasm cutting with electrical snare.

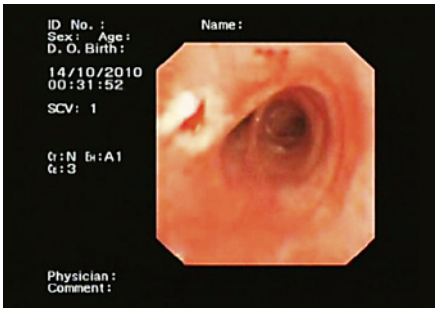

Fig. 6. The base after cutting.

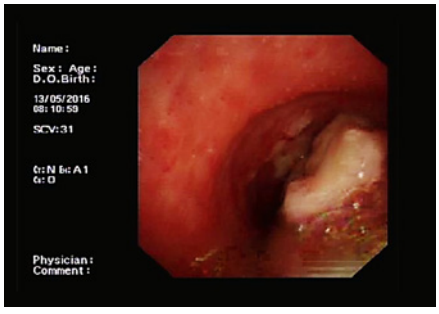

Fig. 7. Intratracheal regeneration, tracheal wall thickening, bulging with regeneration.

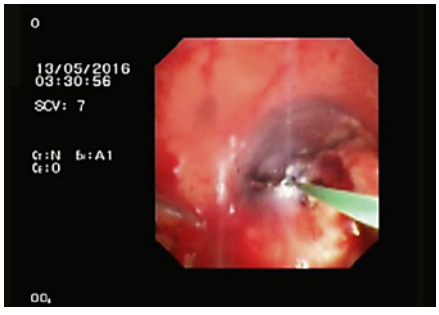

Fig. 8. Laser cauterization.

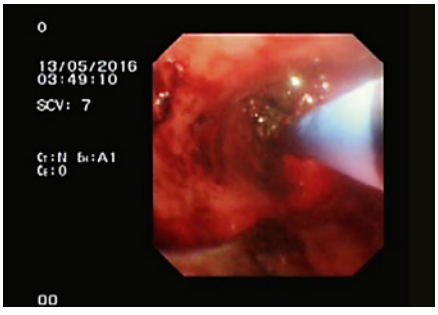

Fig. 9. Argon knife burning.

terventional therapy. It is a combination of a variety of short-acting intravenous anesthetics after intravenous anesthesia induction. Intermittent or continuous intravenous injection is used to maintain anesthesia. It has the characteristics of time controllability and short awakening time. In the monitoring of intravenous anesthesia design intracavitary interventional surgical procedures, we must first consider how to ensure airway patency and oxygenation. It is best to perform general anesthesia and establish artificial airway and mechanical ventilation in the following situations: (1) patients with severe stenosis on trachea, carina, left and right main bronchus, one-sided bronchoconstriction, contralateral lung resection, or obvious pulmonary function disorder or atelectasis; (2) patients with poor general condition, cardiopulmonary dysfunction, and high risk of surgery; (3) patients with airway hemorrhage or lesions rich in blood supply, or patients who may suffer massive hemorrhage during the operation; (4) large lesions that need long-term surgery, and patients cannot tolerate topical anesthesia; (5) patients who panic and cannot accept local anesthesia. There are two forms of general anesthesia during surgery: (1) Using soft bronchoscope when patients are under airtight mechanical ventilation and general anesthesia. This is a relatively safe treatment. The tracheal intubation method requires that the lesion be farther from the glottis (>7 cm), so that the balloon of tracheal intubation can be kept under the glottis and the lower end of tracheal intubation cannot block the lesion. If the lesion is close to the glottis (<5 cm), the tracheal intubation is not easy to fix, or the tracheal intubation is easy to block the lesion, the laryngeal mask should be selected; (2) The other type is rigid bronchoscope or rigid bronchoscope combined with soft bronchoscopy when patients are under open ventilation and general anesthesia, which is a safe treatment for patients with severe airway stenosis. There are two methods of ventilation for rigid bronchoscopes: one is the use of a jet ventilator for non-airtight mechanical ventilation. However, patients under high-frequency jet mechanical ventilator have a high risk of carbon dioxide retention, so it is necessary to monitor the concentration of end-expiratory carbon dioxide during surgery. In patients at risk

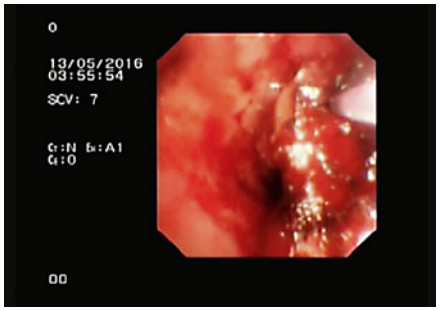

Fig. 10. Needle electric knife cutting.

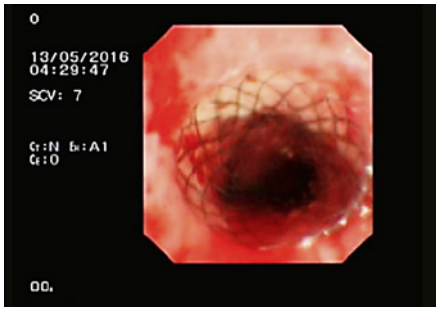

Fig. 11. Placement of a metal stent.

Fig. 12. Eight days after right upper lobe wedge surgery, collapse stenosis of the right main bronchus.

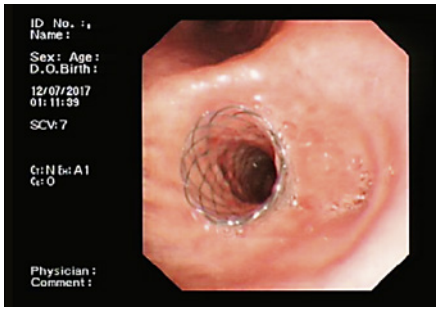

Fig. 13. Placement of a metal stent.

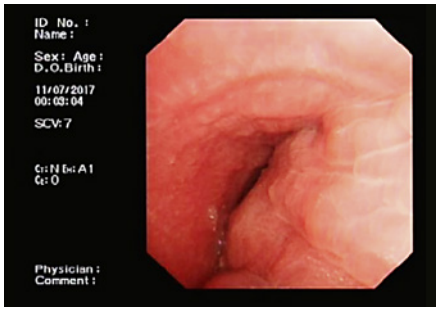

Fig. 14. Fourteen months after esophageal cancer surgery, ichthyoid neovascularization of tracheal mucosa with extrinsic stenosis.

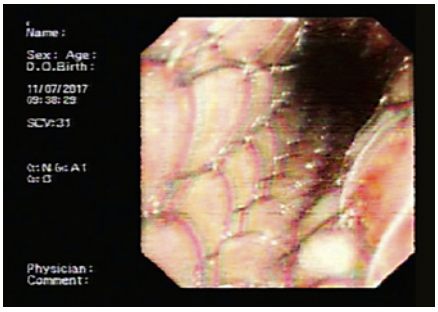

Fig. 15. Placement of a stent graft.

of carbon dioxide retention, as in the case of COPD of an underlying disease or poor lung function, constant frequency ventilation (14–18 times/min) can also be used to help the discharge of carbon dioxide; The other is to use an anesthesia machine, or ventilator for airtight or semi-airtight ventilation (the bronchoscope is inserted through the pipe piston) can also achieve better ventilation. It is also recommended to monitor the end-tidal carbon dioxide concentration during the operation.

(ii) Local anesthesia: It is the most commonly used anesthesia method in clinic, accounting for about 75% of interventional surgery in China. It is suitable for the patients in good general condition, mild tracheal obstruction or unilateral bronchial obstruction, and the operation can be completed in a short time. The advantage of topical anesthesia is that patients who remain awake have a cough reflex and can cough up airway secretions or bleeding. For patients with poor tolerance and difficulty to cooperate, sedative can be added.

4 Principle of the determination of interventional surgery times: The bronchoscopic interventional therapy can be completed in one or several sessions, and this depends on many aspects such as the size of lesions, the relation between the tumor and peripheral tissues, and the amount of bleeding. Smaller lesions, or large lesions with pedicles, can be removed and treated in one session. However, if the lesion is large, the boundary between the lesion and surrounding tissues is not clear, or the amount of bleeding is large, dividing the operation into several sessions might be more appropriate. After the necrotic tissue has been detached, the normal tissue is exposed, or the lesion is decomposed clearly, and then follow-up treatment is performed.

5 The principle for the choice of soft, rigid bronchoscopes or a combination of both. The choice of soft or rigid bronchoscopes depends on the nature, size and location of the lesion, degree of dyspnea, and experience of the operators. If the lesion is large and cannot be removed

in a short time, hemoptysis or asphyxia may occur at any time, or the patient cannot tolerate the awake state for a long time, the operator may choose rigid bronchoscope. The rigid bronchoscope can keep the airway open and carry out collateral ventilation, and there are special treatment instruments such as large optical forceps, foreign body forceps, and argon air knife nozzles and cryoprobes, which contribute to quickly remove lesions or foreign bodies in the airway and open the airway [32]. In addition, some special operations such as placing or removing metal or silicone stents can be performed. For the tumors at the distal or corner of the airway, soft combined rigid bronchoscopes can be used to allow the soft bronchoscope to operate through the rigid bronchoscope channel [33]. In addition, airway stenosis due to certain foreign bodies in the airway and broken metal stents must be treated with a hard bronchoscope. It is not recommended to use a soft bronchoscope [34].

6 The principle for the selection of interventional therapy. The choice of interventional treatment for malignant airway stenosis is best determined by the type of stenosis: (1) For simple intraluminal tumors involving the airway, hot or cold ablation or direct removal by the tip of a rigid bronchoscope can be done (Fig. 4–6). (2) For mixed stenosis, ablation can be used to remove some intraluminal lesions, and then stent implantation might be performed, preferably with a metal stent. If the stent expansion effect is not good, high-pressure balloon dilatation can be used (Fig. 7–11). (3) If it is simple external stenosis, stents can be placed directly. For severe stenosis, balloon dilatation under bronchoscope is feasible, and stents can be replaced after the surgery (Fig. 12, 13). (4) In external compressive stenosis with the invasion of the tracheal wall, the stent with membrane can not only prevent tumor regeneration, but also resist the compressive effect of the tumor (Fig. 14, 15).

The timing of optimal interventional therapy depends on the patient's specific circumstances. In short, for the primary intratracheal tumor, the earlier interventional therapy is performed the better. And in many patients with advanced malignant tumors, severe dyspnea often appears before admission. Here, the principle is to clear the airway and improve ventilation. Bronchoscopic interventional therapy can alleviate stenosis and provide a chance for further treatment such as radiotherapy and chemotherapy, especially for the treatment of tumors that are sensitive to chemotherapy and radiotherapy, such as small cell lung cancer.

In summary, malignant central airway stenosis can be found in a variety of diseases, including the onset of tumors such as lung cancer and other solid tumors. When the obstructed airway develops to a certain extent, the patient has clinical symptoms characterized by dyspnea. In addition to traditional surgery, radiotherapy and chemotherapy, bronchoscopic interventional therapy, such as intraluminal ablation, stent placement, etc., can quickly open the airway to improve ventilation. It is important to emphasize that bronchoscopic interventional treatment for malignant airway stenosis is mostly palliative treatment, which can alleviate symptoms, reduce pain, and prolong life. And it can provide opportunities for follow-up treatment. There are many different methods of transluminal interventional treatment, and the curative effect is similar. The specific selection should take into account the experience, ability, and available resources of the treatment team, the patient's condition, cost, and possible complications. With the increasing number of well-trained interventional pulmonology and critical care medicine physicians in China and the accumulation of clinical experience, patients with malignant airway stenosis will be better diagnosed and treated with endoscopy in the future.

Disclosure Statement

All the authors have no conflict of interest.

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