THE ROLE OF INTERVENTIONAL BRONCHOSCOPY AND STENT PLACEMENT IN THE MANAGEMENT OF TRACHEOBRONCHIAL STENOSIS

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ABSTRACT

Tracheobronchial stenosis, a serious problem in adults and children, has multiple causes and has been treated in many ways. Tracheal strictures are diagnosed by performing a thorough evaluation involving clinical exam, laboratory workup, pulmonary function test, chest imaging and bronchoscopy. Bronchoscopy plays a pivotal role in the diagnosis of stenosis. Surgery is considered to be the primary treatment for benign airway stenosis. Interventional bronchoscopy including mechanical or laser assisted dilation, electrosurgery, airway stenting have been reported in the literature for management of patients who are not surgical candidates.

Keywords: *tracheobronchial stenosis, interventional bronchoscopy, airway stents*

I. INTRODUCTION

Tracheobronchial stenosis is a pathological condition of central airway obstruction, including the trachea and main bronchi, due to structural or functional abnormalities. There are two types of tracheal stenosis: congenital tracheal stenosis (common in children), acquired tracheal stenosis, this type is more common and the most common cause is after prolonged endotracheal intubation, after tracheostomy, etc. [1].

The choice of treatment methods depends on the cause of stenosis, size, degree, location of tracheal stenosis, clinical condition and experience, expertise of the specialist.

The optimal treatment for tracheobronchial stenosis is tracheoplasty. However, many elderly patients with underlying diseases or patients in acute respiratory failure are not candidates for surgery and interventional endoscopy is an effective alternative treatment method. [2]

Stent placement has been developed to address airway stenosis and avoid the potential complications of open surgery. However, the use of metal stents has led to some serious irreversible complications, such as stent fracture and mediastinal invasion. Endoscopic interventional tracheal dilation and airway stent placement using silicone stents has opened up a new method for treating patients with benign airway stenosis.

II. CONTENT

2.1. Classification of tracheal stenosis

2.1.1 Causes

The causes of malignant and benign airway stenosis are listed in the table below.

Malignant airway stenosis is often divided into 3 groups: tumors located entirely within the airway, external compression, and mixed external compression and invasion within the airway. This classification helps us to have appropriate intervention indications.

The most common benign airway stenosis is tracheal stenosis scars after intubation and tracheostomy.

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Malignant	Benign
Lung cancer	Post-endotracheal intubation, tracheostomy
Lung metastasis	Infection (bacterial, fungal, tuberculosis)
Esophageal, mediastinal, lymphoid cancer	Trauma
Laryngeal, nasopharyngeal cancer	Benign tumors, sarcoidosis
After neck radiotherapy	Trachoma bronchiolomas
Congenital (amyloidosis, relapsing polychondritis, etc.)	Trachoma bronchiolomas

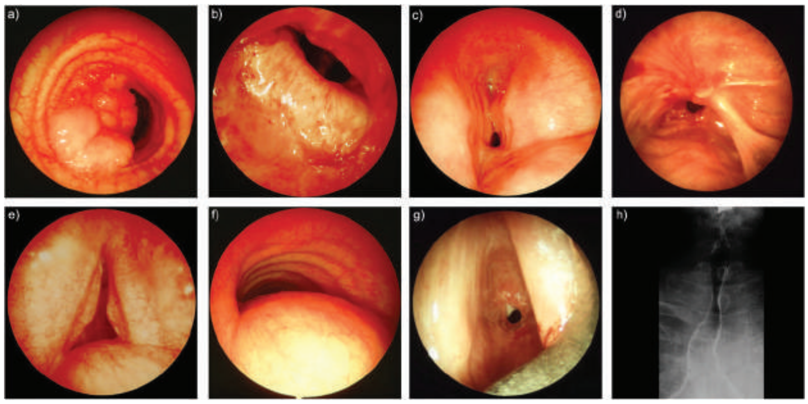

Figure 1. Images of bronchopulmonary stenosis due to various causes [1]

2.1.2. Type of stenosis

According to the classification of Feitag et al. [1]

There are 2 types of stenosis: structural stenosis and functional stenosis.

There are 4 types of structural (entity) stenosis:

1) Benign or malignant endobronchial tumors and granulation tissue

2) Deformation, twisting: due to complications occurring after surgical intervention, transplantation, mediastinal diseases, pleura causing traction

3) External compression is usually lymphadenopathy, goiter, etc.

4) Stenotic scars: stenosis after intubation, tracheostomy, tracheobronchial tuberculosis

There are 2 types of functional stenosis:

1) Chondromalacia

2) Soft posterior wall membrane

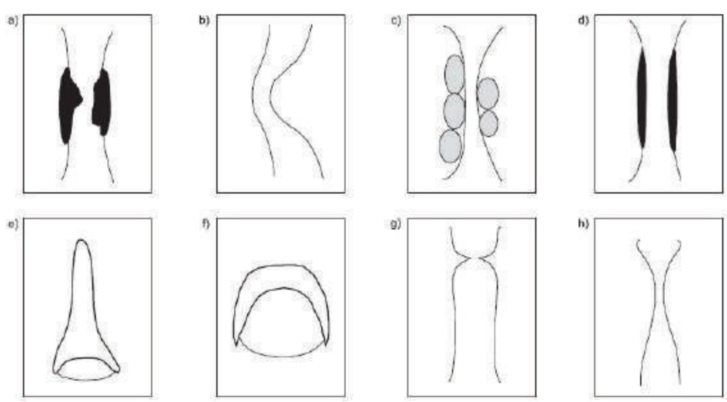

Figure 2. Types of bronchial stenosis [1]

a, endobronchial tumor or granulation tissue; b, deformation; c, external compression; d, stenotic scars; e, scabbard-shaped trachea; f, soft posterior wall; g, web-shaped stenosis; h, hourglass stenosis.

2.1.3 Regarding the location and degree of stenosis

Degree of stenosis: Level 0: 0% stenosis rate, level 1: ≤ 25% stenosis rate, level 2: 26-50% stenosis rate, level 3: 51-75% stenosis rate, level 4: 76-90% stenosis rate, level 5: 91-100% stenosis rate.

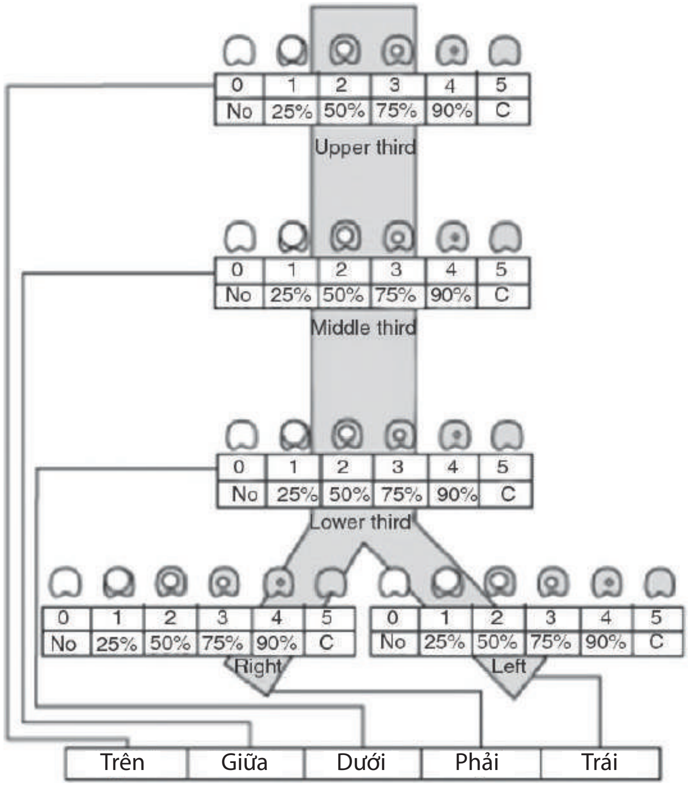

Figure 3. Location and degrees of tracheal stenosis [1]

2.1.4 Classification by stenosis nature

Simple stenosis	Complex stenosis
- Airway mucosa stenosis - Membranous, hourglass-shaped - Short segment < 1cm - No cartilage damage	- Invasive lesions of the tracheobronchial wall - Long segmental stenosis > 1cm - Mixed lesions with protrusion and compression - Tracheobronchial chondromalacia

2.2. Clinical symptoms

The symptoms are often nonspecific and can be confused with other obstructive lung diseases, leading to delayed diagnosis. They may be mild, such as cough and difficulty breathing on exertion. A common sign of tracheal stenosis is difficulty breathing that lasts for weeks or months without an explanation. If the stenosis is severe, there may be severe difficulty breathing. Some have wheezing and hoarseness.

Tracheal stenosis may not have clinical manifestations until the trachea has narrowed to about 50% of its diameter. Therefore, mild cases of stenosis may be accidentally detected on computed tomography (CT), with initial signs being increased cough and difficulty spitting. When the trachea is narrowed to less than 8mm, the patient begins to show signs of difficulty breathing on exertion. When the diameter is narrowed to less than 5mm, signs at rest or wheezing will appear [3].

2.3. Paraclinical

- Chest X-ray: diagnosis of tracheal stenosis on straight - oblique X-ray films, low image quality, many limitations in diagnosis. May be accompanied by images of the cause of stenosis

- Respiratory function: irreversible obstructive ventilation disorder, shown through the flow-volume curve, however, this test is difficult to perform when the trachea is completely or severely stenotic, or the underlying disease is severe.

- Chest computed tomography (CT), especially multi-slice CT: determine the location, extent, and classification of lesions causing stenosis, especially determining the distal end of the stenosis in cases where the endoscope cannot pass, reconstructing the image of the stenosis, and associated lesions. CT also determines any related factors such as a mass outside the neck, but abnormalities of the recurrent plexus nerve or vascular abnormalities.

- Flexible bronchoscopy: Direct visualization of the airway through endoscopy is still the gold standard for definitive diagnosis of tracheal stenosis, allowing assessment of the classification of stenosis, degree and location, biopsy to diagnose the cause of tracheal stenosis, and planning for endoscopic intervention. If the patient has an endotracheal tube or tracheostomy, this tube should be removed to examine the entire airway.

2.4. Treatment

Treatment of tracheal stenosis in the country and in the world is still facing many difficulties. According to foreign documents, up to now, there has been no treatment method considered complete, and the possibility of re-stenosis is still high. Therefore, tracheal stenosis is always a controversial issue in scientific conferences. Current treatments for bronchial stenosis include surgery, stent placement, or a combination of the above two methods, or laser cauterization of stenotic scars, dilation of the stenotic site, etc. The choice of treatment method depends mainly on the patient's diagnosis of the location, length, degree and cause of stenosis [4].

2.5. Interventional rigid bronchoscopy, stent placement

2.5.1. Rigid bronchoscopy

A rigid bronchoscope is a hollow metal tube with beveled edges at the distal end, with many different diameters. Although there has been no significant progress in the rigid bronchoscope since its invention, many instruments have been developed for use through the procedural channel, including rigid and flexible suction tubes, various sizes of forceps, scissors, balloon dilators, high-frequency electrocoagulation tips, lasers, argon and cryotherapy, and stent placement devices.

The patient is placed in the operating room under general anesthesia and muscle relaxation. The patient is placed in a shoulder roll position or with the head of the bed lowered so that the neck can be fully extended. The operator then opens the patient's mouth and carefully inserts the rigid endoscope up to the tongue and hard palate. The operator's thumb is used to support the rigid endoscope just outside the patient's mouth along with the index finger. The endoscope is carefully inserted into the mouth with the bevel pointing up or towards the tongue, advancing into the oral cavity until the uvula is visible. The tip of the endoscope is then lowered and advanced further until the epiglottis is visible. The epiglottis is pushed forward with the tip of the endoscope to expose the cartilages, vocal cords, and glottis. Once the glottis is clearly visualized, the endoscope is rotated 90° to allow the bevel to pass over the vocal cords. The endoscope is then rotated another 90° so that the bevel rests on the posterior wall of the trachea.

2.5.2. Tumor resection and airway dilation techniques

After the patient has been successfully intubated and ventilation has begun. To resolve tracheal stenosis, different techniques can be used depending on the type of tracheal stenosis encountered, external, internal or mixed stenosis. For purely external compressive lesions, without mucosal or endotracheal lesions, only balloon dilation and mechanical dilation with a flexible endoscope tip are needed, followed by placement of a silicone or metal stent to maintain airway patency.

In cases of intrinsic or mixed airway obstruction, the initial goal is to establish airway patency. It is important that the operator maintain good airway observation as well as airway positioning to avoid tracheal perforation and invasion of surrounding mediastinal structures. Once a clear view has been obtained, the airway is properly oriented, and the axis is parallel to the central airway, a decision can be made on how to debulk the obstructing lesion. The first option is to drill the core using a rigid endoscope tip that is rotated forward to remove the lesion from the wall and allow the endoscope to achieve local hemostasis. Ensuring the spatial axis and parallelism is of utmost importance as the endoscope can easily penetrate the airway into the mediastinum. Further options include mechanical debulking with forceps, radiofrequency electrocoagulation, laser or cryotherapy [5].

For simple, membranous tracheal stenosis, we apply a mucosa-sparing technique, using 2-3 radial incisions with laser or radiofrequency electrocoagulation; then dilate with a rigid endoscope tip or balloon. Laser or radiofrequency electrocoagulation should not be applied circumferentially because of the risk of progressive stenosis due to secondary contracture and mucosal scarring [6].

2.5.3. Silicone stent placement technique

Author William Montgomery was the first to use a T-shaped silicone airway stent in 1965. It was not until 1990 that Dumon introduced the first endoscopic airway stent.

There are two main types of endotracheal stents: silicone stents and metal stents.

- Types of silicone stents

Most silicone stents today are based on the original Dumon stent, which is a silicone tube with external studs to reduce migration. Dumon stents come in two main types: straight and Y-shaped. Both stents come in different lengths, diameters and shapes. The shape can be uniform in diameter throughout the length of the stent or hourglass shaped with a narrow center to allow for optimal positioning around the narrowed airway. Silicone stents can also have a smaller diameter tip for optimal positioning. Y-shaped stents come in a variety of diameters for the trachea and bronchi. These stents are usually of uniform length, which can be adjusted at the time of insertion by shortening each of the three limbs to the desired length. Other modifications that can be made at the time of stent placement include cutting holes to allow ventilation of the covered lobar bronchi. Silicone stents can be made of a transparent, radiopaque material, or fused with barium sulfate, which is white, opaque, but radiopaque [7].

Figure 4. Types of silicone stents [7]

- Another type of stent is a self-expanding silicone-coated alloy (nitinol, polyester wire mesh) stent such as the Ultraflex and Polyflex stents (Boston Scientific, Natick, MA, USA). These stents have thin walls resulting in a better internal to external diameter ratio than the Dumon stent. However, because they are not externally attached, they may have a higher rate of migration. There are a few other companies that commercially produce other silicone stents such as those produced by Hood (Hood Laboratories, Pembroke, MA, USA) with similar properties to the Dumon stent [8].

- Biodegradable stents

Biodegradable stents are made from a knitted polymer (e.g. polydioxanone) that degrades when placed inside the airway, making bronchoscopy unnecessary. They maintain their biomechanical strength for six weeks and completely dissolve after three to four months. Biodegradable stents may be useful for airway conditions that require temporary stent placement. Appropriate indications may include airway stenosis secondary to anastomotic complications associated with lung transplantation, treatment of airway fistulas, or potentially treatable benign strictures [9].

Indications for stent placement

There are several indications for the use of silicone stents in the treatment of tracheal stenosis. In general, silicone stent placement is indicated to maintain central airway patency due to malignancy and benign conditions that cause tracheobronchial stenosis (usually >50%) [8].

- For cases of tracheal stenosis due to malignancy: it can be external compression, endotracheal tumor, or a combination of both. For tracheal stenosis due to external compression, stent placement helps maintain airway patency when external compression occurs. For cases of tracheal stenosis due to intrinsic tumors or combined compression and invasion of the tumor into the airway, stents are placed after resection and destruction of the tumor to maintain patency and avoid recurrent obstruction due to tumor growth.

- For cases of benign tracheal stenosis due to sequelae after intubation, tracheostomy, post-tuberculosis of the airway, tracheobronchial chondromalacia, etc.

- To cover airway-esophageal or airway-mediastinal fistulas due to malignancy, etc.

Technique:

When airway lesions (compression, tumors, stenotic scars, etc.) have been dilated, resected, or destroyed and the decision to place a silicone stent has been made, steps must be taken to ensure appropriate, safe, accurate, and timely stent placement. The stent placement technique is based on the technique of Jean Francois Dumon (1990) [10].

The first step is to select the appropriate stent size and length. This is important because proper sizing reduces the risk of stent migration and the formation of granulation tissue, airway fistula, or difficulty in deployment (oversizing). The length and diameter of the stent can be estimated using a chest CT scan prior to the procedure, however, measurement during bronchoscopy is the most accurate way to measure stent size. The stent diameter is usually determined by selecting a size similar to the largest outer diameter of the rigid bronchoscope used to maximize lesion dilation. Stent sizing kits for rigid bronchoscopes can also be used. The stent length should be 5-10mm proximal and distal to the lesion measured using an optic or flexible bronchoscope.

Once the appropriate stent has been selected, it will be inserted into the hollow metal tube containing the stent through a specialized stent feeder. Then, the rigid bronchoscope is placed slightly away from or within the stenosis. Insert the metal tube containing the stent into the rigid bronchoscope, and use a tool to push the stent out of the rigid bronchoscope into the trachea. If the bronchoscope is placed far from the lesion, the rigid bronchoscope can be pulled out a little while pushing the stent out to put the stent in the right stenosis. Then, use forceps to adjust the stent into the right stenosis, ensuring that the upper and lower ends of the stent are clear, and the stent lumen is clear.

Complications

There are many complications related to rigid bronchoscopy and stent placement. Acute complications related to the procedure: trauma to the oral cavity, vocal cords, bronchial asthma, bleeding, infection, tracheobronchial rupture, respiratory failure, pneumothorax, mediastinum, etc. Late complications related to stent placement: mucus retention, stent displacement, granulation tissue formation, restenosis, etc.

III. CONCLUSION

Tracheal stenosis is a life-threatening condition that requires early intervention. The optimal treatment for tracheal stenosis is tracheoplasty. However, in many elderly patients with underlying medical conditions or patients with acute respiratory failure who are not candidates for surgery, endoscopic interventional dilatation, high-frequency electrocoagulation, laser and stenting are effective alternative treatments.

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