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Biopsy and interventional therapy of subglottic lesions with flexible bronchoscope under protection of endotracheal intubation

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Abstract

Subglottic lesions represent a complex and challenging clinical entity, often associated with high procedural risks due to their anatomical location and vascularity. While a laryngeal mask airway (LMA) is commonly employed for airway management in such cases, it has notable limitations, particularly in scenarios involving significant bleeding or the need for extended intervention. This article presents an alternative and effective approach for the biopsy and interventional treatment of subglottic lesions using a flexible bronchoscope under the protection of an endotracheal tube (ETT). By inserting the bronchoscope through the space between the ETT and the tracheal wall, various procedures—including biopsy, argon plasma coagulation (APC), and CO_2 cryotherapy—can be performed with relative safety. This method provides a feasible option for airway protection, bleeding control, and lesion management, offering new possibilities in clinical practice.

Keywords Bronchoscopy, Subglottic lesions, Endotracheal intubation, Laryngeal mask airway

Introduction

Various benign and malignant airway diseases, especially central airway diseases, can result in various clinical symptoms, including coughing, wheezing, dyspnea, and recurrent airway infections distal to the lesion [1]. In addition, central airway diseases are usually rich in blood supply and can cause fatal bleeding when the lesion ruptures. Without timely intervention, asphyxia and even death can occur at any time [2]. Therefore, central airway diseases require early intervention.

The rigid bronchoscope has a large orifice for easy operation while maintaining airway patency and respiratory support [2]. If there is heavy bleeding during the operation, a large-aperture suction tube can be used to ensure a clear field of view, while argon plasma coagulation (APC), high-frequency electric knife (HFEK), and laser photocoagulation are utilized to stop the bleeding. In addition, the sharp angle at the tip of the hard metal bronchoscope tube allows for direct"removal"of the tumor under the bronchoscope [3]. Therefore, rigid bronchoscopy is often the first choice for treating central airway diseases [4].

However, the subglottic lesion poses a challenge to rigid bronchoscopy due to the restricted field of view. When dealing with subglottic lesions, a laryngeal mask

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airway (LMA) is usually used for airway management. The LMA facilitates the insertion of the flexible bronchoscope at the level of the glottic opening and provides excellent visualization of the anatomy and dynamics of the glottis, subglottic area, and other parts of the airway. It also maintains airway patency during general anesthesia, permitting spontaneous respiration and allowing for assisted ventilation if necessary [5]. Therefore, an LMA combined with a flexible bronchoscope is the most common choice for these lesions [6].

But the use of LMA has some shortcomings. When the blood supply of the lesion is abundant and intraoperative bleeding occurs, it is hard to control the bleeding and ensure adequate ventilation with an LMA [7]. Although the rapidly developing vascular interventional techniques in recent years can effectively reduce the risk of bleeding by embolizing the lesion vessels to achieve preoperative prevention or intraoperative hemostasis, there will always be various circumstances that limit its application [8]. For example, the onset of subglottic lesion is often ferocious. Patients tend to visit grass-roots hospitals, and it is difficult for them to tolerate long-distance transport. In addition, the medical unit lacks the means to perform bronchial artery embolization, the condition is too urgent to allow for vascular intervention, or the patient has an iodine allergy.

This paper will report a safe and effective method for biopsy or interventional therapy via a flexible bronchoscope under the protection of endotracheal intubation. A flexible bronchoscope was placed in the gap between the endotracheal tube (ETT) and the trachea. Biopsy forceps, APC, CO_2 cryotherapy, and other equipment were used to perform operations, such as biopsy and tumor removal through the working orifice of the flexible bronchoscope. Balloon incarceration in the distal airway of the lesion can effectively prevent the mass from falling off and the risk of suffocation caused by severe bleeding (Fig. 1).

Methods and results

Patient 1

A 45-year-old female with an 8-day history of hemoptysis was admitted to the respiratory department on October 12, 2019. She had a history of thyroidectomy 6 years prior and was known to be allergic to iodinated contrast media. Chest computed tomography (CT) revealed a mural nodule in the upper trachea, approximately 1 cm below the glottis. Bronchoscopy identified a subglottic nodular bulge arising from the airway mucosa, which appeared hypervascular (Fig. 2A).

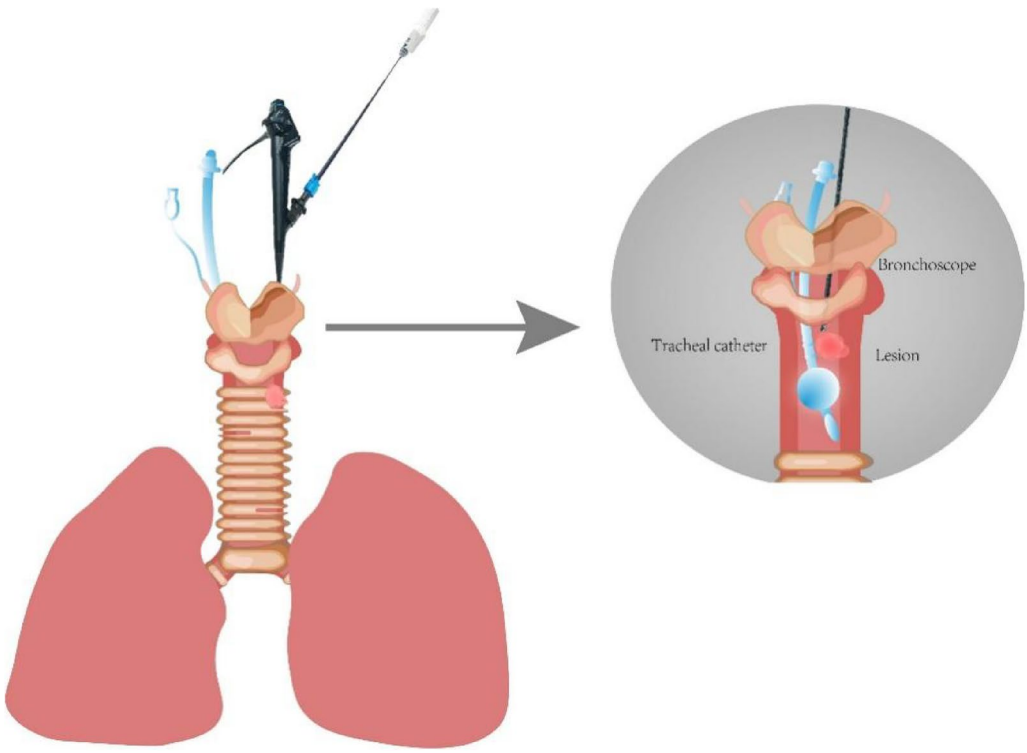

Fig. 1 Schematic diagrams of this method

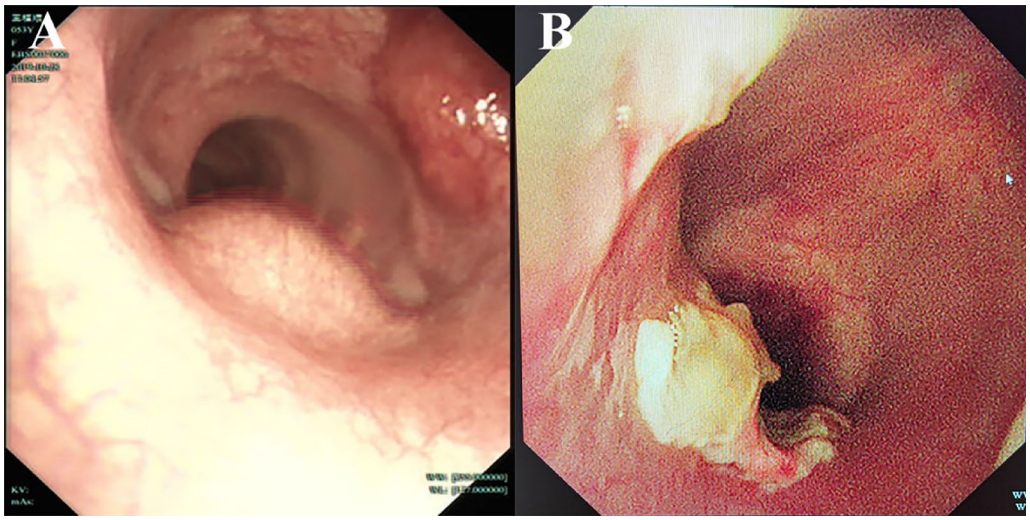

Fig. 2 **A** Subglottic lesion of patient 1; **B** Subglottic lesion of patient 2.

Patient 2

A 62-year-old male was admitted to the respiratory department on August 02, 2021, with a 40-day history of intermittent dyspnea. His medical history included radical surgery and chemoradiotherapy for small cell lung cancer 3 years earlier, as well as rigid endotracheal tumor resection performed 1 year prior to admission. One month before admission, the patient experienced a sudden episode of coma lasting about 1 h and underwent emergency tracheal intubation. Following the procedure, he developed recurrent hemoptysis. Bronchoscopy performed in July 2021 revealed a subglottic mucosal bulge (Fig. 2B). Based on chest CT conducted 2 weeks prior to symptom onset, upper airway tumor invasion was suspected. It was presumed that the majority of the tumor tissue had been dislodged during the intubation process.

Preoperative consideration

In both cases, a thorough preoperative evaluation was conducted to determine the most appropriate interventional strategy. Several commonly used approaches for the management of subglottic lesions were carefully assessed. The risks and feasibility of each method were thoroughly explained to the patients, and informed consent was obtained prior to the procedure.

Patient 1 had a known allergy to iodinated contrast media, which made vascular embolization infeasible. She also declined awake intubation due to anxiety and poor tolerance. Rigid bronchoscopy was considered but abandoned, because the lesion was located only 1 cm below the glottis, leaving insufficient operating space for the rigid scope tip. LMA, though commonly used in such procedures, was also deemed unsuitable due to the rich vascularity of the lesion and the high risk of intraoperative bleeding that would be difficult to manage via LMA ventilation.

Patient 2 had a complex medical and surgical history, including radical resection and radiotherapy for small cell lung cancer 3 years earlier and rigid bronchoscopic tumor resection 1 year earlier. Due to the proximity of the lesion to the acoustic hilum, rigid bronchoscopy was deemed unsuitable due to limited surgical space. In addition, the anesthesiologist was concerned that positive pressure ventilation through the anesthesia machine might be compromised, which could lead to inadequate oxygenation. Intraoperative bleeding is also difficult to control with LMA-assisted ventilation.

Both patients had subglottic lesions. Finally, we chose to apply flexible bronchoscopy under the protection of tracheal intubation for biopsy sampling in patient 1 and biopsy sampling and partial removal of tumor tissue in patient 2.

Anesthesia

To reduce the stress response during intubation, lidocaine cream was applied to lubricate the ETT. General anesthesia was induced with intravenous administration of etomidate, alfentanil, and atracurium. Anesthesia was maintained using a combination of propofol, remifentanil, and sevoflurane. Epinephrine was prepared in advance as a rescue medication in case of emergency. ETT 4.5 (Covidien, Origin: Shanghai, Model: 18,860, OD 6.6 mm, ID 4.5 mm) was selected, and tracheal intubation was performed under the guidance of a flexible bronchoscope. Under direct vision, the ETT was seen to cross the distal end of the lesion by approximately 2–3 cm. The

balloon was then inflated until the trachea was incarcerated (Fig. 3). The proximal end of the ETT is connected to a ventilator to maintain breathing;

Biopsy and interventional therapy

The flexible bronchoscope (Olympus, OD 5.5 mm, ID 2.8 mm) was placed in the gap between the ETT and the trachea. Various treatments can be performed through the working orifice of the flexible bronchoscope. Balloon incarceration in the distal airway of the lesion can effectively prevent the mass from falling off and the risk of suffocation caused by severe bleeding (Fig. 4A–D).

In patient 1, the bleeding volume after the biopsy was about 90 ml, which was stopped by 1:1000 epinephrine plus 4 °C ice physiological saline and APC. During the operation, the patient had stable oxygenation and blood pressure and no significant bleeding from the distal airway after removing the tracheal intubation balloon. The operation time was near 32 min. In patient 2, In the second case, the bleeding volume was about 10 ml after the biopsy, followed by CO_2 cryotherapy and APC to eliminate part of the tumor tissue. The operation time was 45 min.

Discussion

In clinical practice, biopsy or intervention for the subglottic lesion can be a high-risk and challenging task. As far as we know, we are the first to report this method, which is relatively safe, practical, feasible, and easy to apply. Undoubtedly, the most significant disadvantage of this method is that the ETT occupies airway space, which limits bronchoscopy, while the limited operating space might make it difficult to use thermal therapy, such as laser therapy or APC near flammable tubes. Therefore, we recommend choosing an ETT with an ID of 4.5 mm to reserve space for subsequent surgery, which can avoid the exposure of thermal therapy to the flammable ETT as much as possible. In addition, microlaryngoscopy tubes (MLTs), which are specifically designed for airway procedures in narrow spaces, may serve as a safer and more standardized alternative to conventional ETTs. Their potential advantages in minimizing space occupation and improving intraoperative safety warrant further exploration in future practice [9].

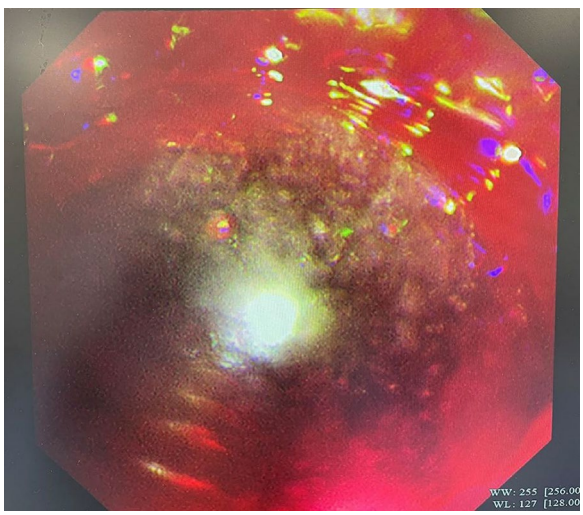

Fig. 3 This inflated balloon has firmly blocked the distal end of the trachea

In fact, including the above two cases, we have also used this approach to remove granulation by laser therapy in a patient who developed a stricture above the incision with a post-tracheostomy (Fig. 5A). Previous experience showed that the patient had severe subglottic capillary leakage and that the lesion was prone to bleeding when touched. It is worth noting that, clinically, when faced with this situation, silicone stents were mostly chosen to be placed in the airway. However, severe granulation tissue growth can still occur after stent placement [10]. Therefore, we first performed balloon dilation (diameter 15 mm) at the airway stenosis and then treated the lesion with laser therapy using the method described above. Remarkably, the procedure went very well, and the airway recovered well at the 6-month follow-up that has continued since the surgery (Fig. 5B). Subglottic stenosis remains a particularly challenging condition due to the narrow anatomical structure and risk of airway compromise. Di Felice et al.'s retrospective comparison of rigid bronchoscopy versus flexible bronchoscopy under general anesthesia found no significant differences in outcomes [11]. Although rigid bronchoscopy offers advantages in instrument capacity, the widespread availability and relative simplicity of balloon catheters delivered through flexible bronchoscopes make this approach more accessible, particularly for operators without specialized training in rigid techniques [12].

When encountering subglottic masses, several approaches are commonly considered, including rigid bronchoscopy, awake fiberoptic bronchoscopy, bronchial artery embolization, and flexible bronchoscopy with LMA. Among these, awake fiberoptic bronchoscopy is considered one of the safest options as it preserves spontaneous breathing and patient awareness. However, in therapeutic procedures that require prolonged operation time, patients may experience significant discomfort, and lack of cooperation can increase the risk of airway injury. In addition, Chang et al. conducted a study on 49 patients with laryngeal lesions who underwent carbon dioxide laser surgery. They found that while there was significant improvement in voice function for patients with benign lesions and Reinke's edema, limitations in tolerance and

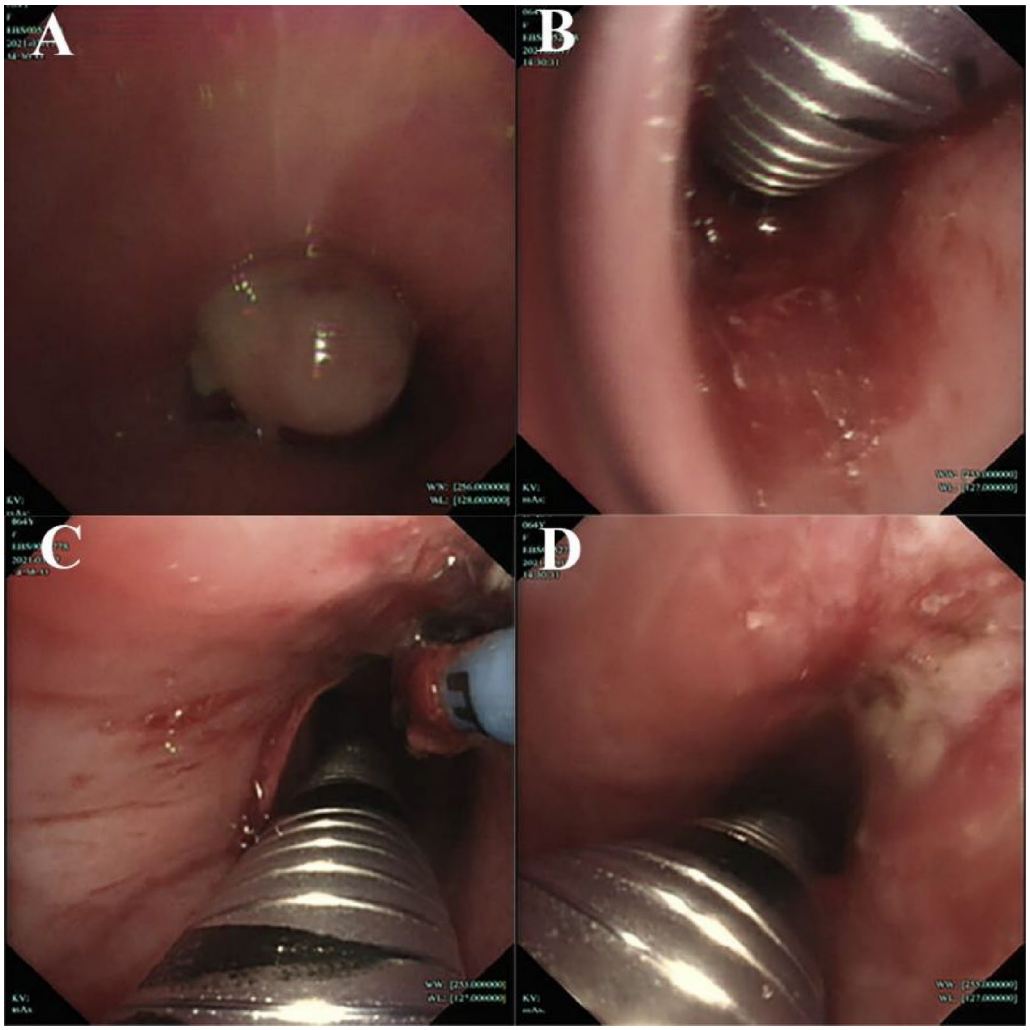

Fig. 4 **A–B** we placed the tracheal catheter to the distal end of the lesion and inflated the distal end; **C**under the protection of tracheal intubation, a fiberoptic bronchoscope was used to extract and biopsy the lump; **D** after the treatment, we withdrew the fiberoptic bronchoscope and tracheal catheter from the airway

therapeutic efficacy were observed [13]. This may be analogous to awake fiberoptic bronchoscopy, which could be a safer choice for lesions with shorter expected procedural times, provided the patient has a high tolerance. Notably, for patients with anticipated difficult airways, awake fiberoptic bronchoscopy via the oral route may also be a viable option [14]. Rigid bronchoscopy offers a wide operating channel and relatively safe airway control, but it is often unsuitable for subglottic lesions due to limited accessibility and may cause mechanical trauma to the airway. LMA-assisted bronchoscopy maintains ventilation and offers procedural flexibility but is not ideal for highly vascular lesions, where bleeding is difficult to control through LMA ventilation alone. For hypervascular tumors, bronchial artery embolization may be effective in reducing intraoperative bleeding. However, this technique does not provide histological diagnosis or immediate lesion removal. In addition, embolization is contraindicated in patients with contrast agent allergies, as was the case in Patient 1. Comparison of Different Management Techniques for Subglottic Lesions shown in Table 1.

Potential complications of our method include airway trauma due to repeated scope manipulation, thermal injury from the use of APC or laser therapy near the ETT, and anesthesia-related events, such as hypotension or delayed recovery. To minimize these risks, we emphasize the importance of careful patient selection and continuous intraoperative monitoring of hemodynamic parameters. The procedure should be performed by a team

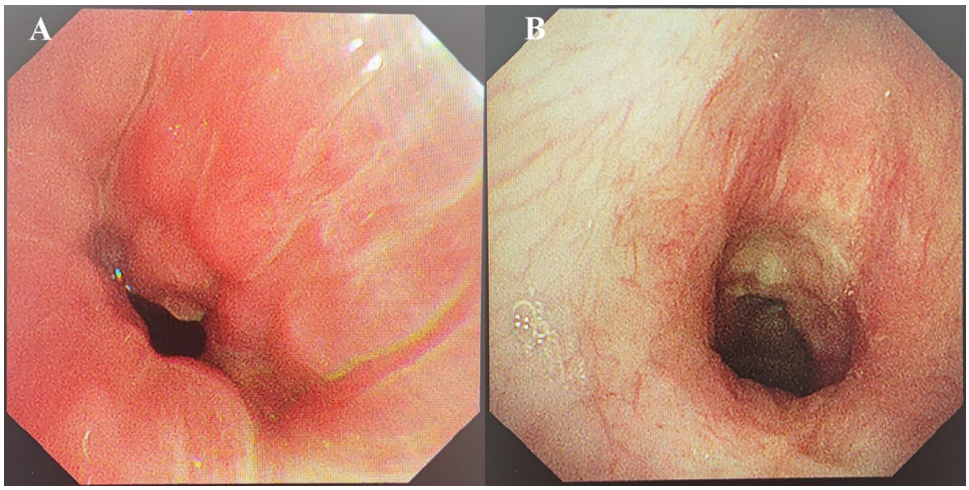

Fig. 5 **A** Before treatment, the patient had severe subglottic stenosis; **B** This treatment augments the airway and restores airway patency

Table 1 Comparison of different management techniques for subglottic lesions

Technique	Advantages	Disadvantages
Flexible bronchoscope under ETT Protection	- Good visualization of the subglottic area - Balloon tamponade enables bleeding control - Minimizes risk of tumor dislodgement	- Limited operative space - Requires experienced bronchoscopist and anesthesiologist - Requires tolerance to general anesthesia
Flexible bronchoscope with LMA	- Preserves spontaneous respiration - Suitable for short diagnostic procedures and therapeutic interventions	- Ineffective bleeding control
Rigid bronchoscope	- Wide working channel - Suitable for resection of large or hemorrhagic lesions	- Limited visualization of subglottic area - Higher risk of airway trauma
Interventional embolization	- Minimally invasive - Effective for hypervascular lesions	- Contraindicated in patients with iodine allergy - Not allow biopsy or lesion resection
Awake fiberoptic intubation	- Contraindicated in patients with iodine allergy - Does not allow biopsy or lesion resection	- Poor patient comfort - Requires patient cooperation

experienced in both bronchoscopy and airway management. In addition, airway management plays a critical role in this patient population. In both cases presented, oxygen saturation remained stable above 90%, end-tidal CO_2 ($EtCO_2$) levels were within the normal range (35–45 mmHg), and peak airway pressure did not exceed 30 cmH_2O. These parameters indicate that adequate ventilation was maintained despite the use of a narrow-bore ETT. Rescue medications and airway management tools were also prepared in advance to promptly address any unexpected complications.

Recently, Wang proposed a new classification method for the central airway, suggesting that the central airway should be divided into three equal areas: I, II, and III. The carina is classified as the IV zone, and the right central and middle bronchus are the V and VI zones. The left principal bronchus is divided into VII and VIII zone [15]. This classification method helps us select the distal location of the ETT according to the location of the lesion. The method proposed in this paper requires ensuring that the inflatable balloon is firmly occluded distally while maintaining oxygenation, which is primarily applicable to lesions in the I, II, and the upper half of the III zones, especially those in zone I (subglottic airway). Although we have not tried it, we believe this approach also applies to lesions located in zone IV or lower zone III. At this point, we can insert the distal end of the ETT into the right main bronchus or the corresponding trachea with more effective lung tissue as determined by chest CT and allow balloon inflation to embed the distal end. Of course, this procedure may sometimes require splicing of the ETTs (customized ETT assembled by connecting 5.5 mm and 6.0 mm ID tubes) (Fig. 6). However, we have not yet applied this technique to distal lesions in clinical practice, and we acknowledge that the spliced ETT design may carry

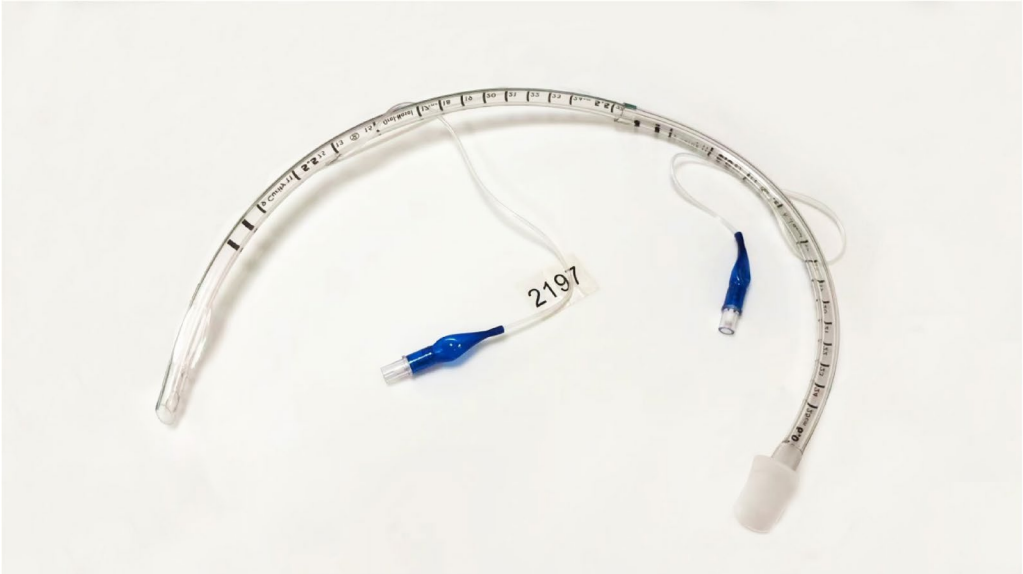

Fig. 6 A long tracheal tube formed by splicing two tracheal tubes

a risk of dislodgement. Further studies are required to assess the safety, feasibility, and stability of this approach in such cases.

We believe that biopsy or interventional treatment of subglottic lesions or even all central airways lesions with a flexible bronchoscope under the protection of ETT is safe, effective, and feasible. The proposal of this method will help solve the dilemma caused by the inability to ensure the safe implementation of rigid bronchoscopy or the inability to perform interventional vascular therapy and may also provide more options for the urgent treatment of the subglottic lesion. However, its efficacy may be limited in cases involving bulky tumors causing near-complete obstruction, or when balloon occlusion is technically unfeasible. Before performing this approach, we must communicate in detail with the anesthesiologist to assess the feasibility of this surgical approach applied to each patient. Furthermore, when some centers are not equipped to handle complex central airway lesions, patients should be rapidly transferred to an appropriate medical facility. Further multicenter studies are still needed to follow up to determine whether this approach can be safely and effectively applied to different institutions and patient populations.

Author contributions

(I) Conception and design: H li; (II) Administrative support: H li; (III) Provision of study materials or patients: H li, H Lin, T Ji; (IV) Collection and assembly of data: T Ji, H Lin;(V) Data analysis and interpretation: T Ji, H Lin, H Zheng, W Ma, S Song, Y Zheng, D Yu, L Ye; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Availability of data and materials

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Written informed consent was obtained from the patients for the publication of any potentially identifiable data or clinical images. As this report involved a retrospective description of clinical cases with no additional risk to the patients, ethical approval was waived by the Institutional Review Board.

Competing interests

The authors declare no competing interests.

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