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CASE REPORT

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Cardiopulmonary crisis caused by bronchial blocker malposition in a patient with aberrant tracheal anatomy: a case report

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Abstract

Background Double-lumen tubes (DLTs) and bronchial blockers (BBs) can be used to establish one-lung ventilation (OLV) for thoracic surgery. BBs are a good alternative when DLTs are not suitable or patients have difficult airways. However, BBs are more prone to malposition, leading to adverse events.

Case presentation We present a 68-year-old male patient who was scheduled for thoracoscopic left lower lobectomy. The patient was not expected to have airway malformation preoperatively. When the DLT could not be inserted into the bronchus after general anesthesia induction, we used a BB to perform OLV. During surgery, malposition of the BB resulted in the development of an "incomplete balloon valve", leading to a cardiopulmonary crisis.

Conclusions Previewing chest computed tomography scans to assess the airway anatomy before thoracic surgery is essential. Three-dimensional reconstruction of the airway can provide a more intuitive assessment of airway anatomy. During OLV with BBs, we should pay attention to balloon malposition to prevent cardiopulmonary crises.

Keywords Double-lumen tube, Bronchial blocker, One-lung ventilation, Airway malformation, Airway management

Introduction

One-lung ventilation (OLV) is highly practical because it can provide clear surgical access. Double-lumen tubes (DLTs) and bronchial blockers (BBs) are the most common devices used for OLV. Clinically, DLTs are the first choice for anesthesiologists and used to be the gold standard for OLV in adults [1]. The use of BBs to achieve OLV is increasing worldwide, especially in the context of DLTs failing to establish OLV or the presence of difficult airways [2]. However, BBs cause unanticipated emergent conditions due to malposition in patients with anatomical tracheal malformations. In this paper, we report a patient who underwent thoracoscopic surgery and experienced an airway crisis resulting from an "incomplete tracheal ball valve" due to tracheal distortion and stenosis.

Case presentation

A 68-year-old male patient with a height of 170 cm and a weight of 77 kg was scheduled for thoracoscopic left lower lobectomy. His history included 40 years of smoking, hypertension, and right internal carotid artery conclusion along with other comorbidities. Pulmonary function testing revealed moderate to severe mixed ventilation impairment. Preoperative airway assessment revealed a Mallampati grade II without any high-risk characteristics for difficult airway management.

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On arrival at the operating theatre, the standard monitoring was initiated based on American Society of Anesthesiologists recommendation, including electrocardiogram, heart rate, peripheral pulse oximetry, and noninvasive cuff blood pressure. Subsequently, an arterial catheter was inserted into the right radial artery for invasive arterial pressure monitoring. According to his height and weight, we decided to insert a 37.0 French left-sided DLT for OLV based on empirical evidence. General anesthesia induction was performed by intravenous administration of sufentanil, cis-atracurium, etomidate, and lidocaine. The DLT was inserted into the trachea via a video laryngoscope. However, when the DLT was advanced approximately 20 cm away from the incisor, we felt significant resistance to the advancement of the tube. Considering that the outside diameter of the 37.0 French DLT may be too large, we decided to replace it with a 35.0 French left-sided DLT. However, a similar resistance was also encountered. After several unsuccessful attempts, we removed the DLT and continued mask ventilation, adhering to the principle of airway safety first. Considering the presence of tracheal stenosis, we inserted an 8.0 mm single-lumen tube (SLT) into the trachea and then attempted to insert a 9.0 French BB (Tappa Medical Technology Co., Ltd, Hangzhou, China. Figure 1) through the SLT in an intraluminal manner. After the fully lubricated BB was inserted into the SLT, a 2.8 mm diameter fiberoptic bronchoscope (FOB) was inserted to guide the insertion position of the BB. However, the BB was always prone to entering into the right bronchus instead of the left bronchus. By turning the patient's head to the right, pressing the cricoid cartilage, and reshaping the angle of the BB tip, we inserted the BB into the left bronchus under the direct vision of FOB. It took nearly 1 h to establish OLV. After confirming the establishment of lung isolation, we fixed the SLT and the BB, placed the patient in the right lateral position, and reconfirmed the position of the BB via the FOB. Then, the surgery began.

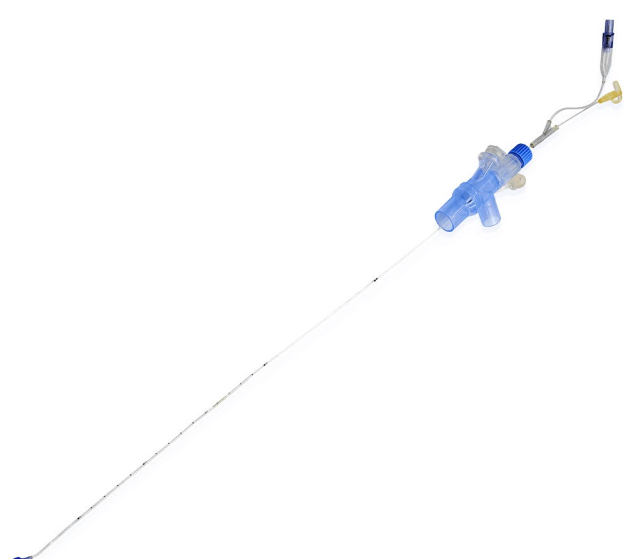

Fig. 1 The bronchial blocker we used in this case

Approximately 15 min later, the anesthesia machine suddenly alarmed for increased airway pressure. No bending was found in the SLT, and only a small amount of sputum was sucked from the trachea, but the airway pressure was still high. Subsequently, the patient's oxygen saturation and blood pressure decreased progressively, and the surgeon noticed that the left lung had significantly inflated. We immediately stopped the surgery and checked the position of the BB by FOB, finding that the endobronchial balloon had been malpositioned, backed out of the left main bronchus, and the trachea was almost completely occluded. We deflated the balloon and resumed two-lung ventilation soon. The airway pressure returned to normal immediately. Following the vital signs returned to normal, the BB was repositioned via an FOB, and the OLV was re-established. The surgery lasted for 160 min, and the patient was discharged 4 days later uneventfully.

Discussion

DLTs and BBs have been widely used in OLV. Compared with BBs, the advantages of DLTs are as follows: shorter placement time, faster onset of lung collapse, easier suctioning, and lower incidence of malposition [3]. Therefore, we initially planned to choose a DLT for this patient. But it failed. Since the lack of reviewing the chest computed tomography (CT) scans to assess the airway preoperatively, we suspected that the patient had tracheal stenosis. Repeated attempts to insert a DLT into the trachea would increase the risk of tracheal injury. This phenomenon is precisely one of the indications for BBs. After reviewing the chest CT scans postoperatively, along with a three-dimensional reconstruction of the airway, we found that the trachea had anti-S-shaped distortion (Fig. 2A). The middle-lower segment of the trachea was severely narrowed, and the cross-section was oval (Fig. 2B and C). The narrowest area measured only 6–7 mm (Fig. 2D). However, the outer diameter of a 37 French DLT is 12.3 mm, so it cannot be inserted into the bronchus through the narrow section. In the case report conducted by Li et al., a patient with upper tracheal stenosis was scheduled for a video-assisted thoracoscopic lobectomy. The narrow trachea allowed only a smaller diameter SLT to pass through. While a BB and FOB could not pass through the small tube simultaneously. They inserted a 7.0 French BB into the trachea under direct visualization with a video laryngoscope first, followed by inserting a smaller SLT with an inner diameter of 5.5 mm, through which an FOB was inserted for adjusting the BB to the bronchus [4]. Fortunately, the narrow segment in

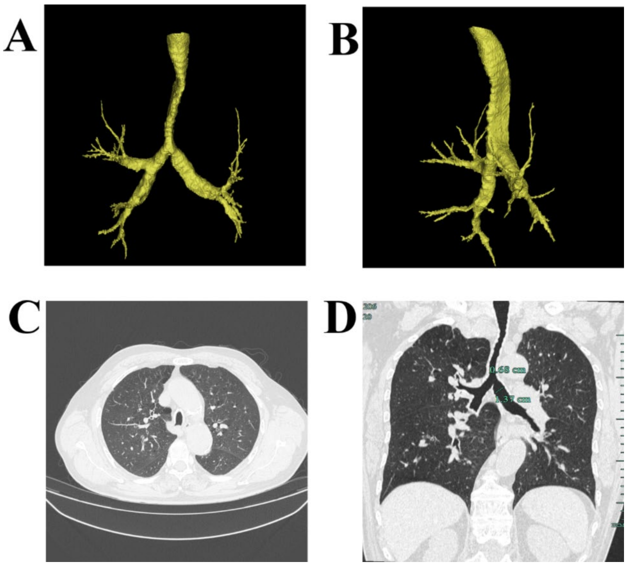

Fig. 2 **A** Front view of the 3D reconstruction of the airway; **B** Side view of the 3D reconstruction of the airway; **C** The image of the cross-section of the middle and lower trachea; **D** The inner diameter of bronchus and trachea

this case was located in the middle-lower segment of the trachea. The process of placing the BB was also not smooth. Because the catheter of the BB was slightly hard, its tip would be inserted into the right bronchus along the curvature after passing through the upper segment of the trachea.

Reviewing the chest CT scans for airway assessment before surgery is an essential part of thoracic surgical anesthesia. We used to select the size of the DLT based on gender, height, and weight. However, the correlation of these characteristics and tracheobronchial dimensions is poor [5]. The inappropriate size of the DLT will not only lead to intubation failure but also increase the risk of airway injury. Currently, it is believed that the methods of measuring the diameters of the cricoid ring and bronchus [6] and the distance between the carina and vocal cord [7] according to the chest CT scans can guide the selection of a suitable size DLT and the estimation of the depth of intubation, thereby improving the success rate of intubation, reducing the time of intubation, and decreasing the incidence of sore throat and airway injury. Additionally, software platforms, such as Synapse Vincent (Fujifilm) and Mimics Software (Materialise), can perform three-dimensional reconstruction of the chest CT scans to provide an intuitive display of the airway structures, which facilitates the planning and management of OLV.

Regardless of whether DLTs or BBs were used for OLV, malposition is always a serious issue, especially after changing the patient's position. It can even cause life-threatening events. The incidence of BBs malposition is greater than that of DLTs (33% vs. 14%) [8]. Therefore, after changing from the supine position to the lateral position, we used an FOB to reconfirm the position of the BB (Fig. 3A). However, malposition still occurred during the surgery, possibly related to left lung manipulation. Sandberg et al. reported a case of BBs malposition during surgery, where the balloon backed out of the mainstem bronchus into the trachea, forming a "tracheal ball valve". In the condition of positive pressure ventilation, this valve caused severe air trapping rapidly, leading to an increase in intrathoracic pressure, resulting in pulseless electrical activity in the patient [9]. The cross-section of the normal trachea is approximately circular, and the whole trachea is cylindrical. However, unlike in the case of Sandberg, the balloon could not completely back out of the bronchus into the trachea in this case, due to the patient's elongated elliptical tracheal cross-section (Fig. 3B). Therefore, it did not form a "tracheal ball valve" immediately but instead created an "incomplete tracheal obstruction" (Fig. 3C and D), resulting in a delayed progressive decrease in blood oxygen saturation and blood pressure. Because in the early stage after the BB malposition, the anesthesia machine could still deliver air into the right lung through the incompletely obstructed tracheal. However, the air could not be completely expelled during expiration, forming auto-PEEP and resulting in a gradual increase in airway pressure. The driving pressure for positive pressure ventilation of the anesthesia machine also increased. At this time, although the left bronchus was in an isolated state, a small amount of air was squeezed into it through the gap between the balloon and the bronchial wall, forming a "bronchial ball valve". Therefore, apart from an increase in airway pressure, there would be no significant changes in vital signs initially, making it difficult to detect the malposition in time. With time, the oxygen saturation would progressively decrease due to inadequate ventilation, and the left lung would gradually inflate. Finally, as the intrathoracic pressure gradually increases, the left ventricular preload would decrease, leading to a decrease in cardiac output, and affecting hemodynamics.

Intraoperative hypoxemia is a common adverse effect during OLV in thoracic surgeries, with an incidence ranging from 3–28% [10, 11]. The malposition of DLTs or BBs is one of the main reasons, and timely identification and repositioning can correct hypoxemia. FOB is considered as the gold standard for assessing the position of the tube. However, we do not frequently use it to check the tube during surgery. Thus, the diagnosis of malposition is usually delayed, often being discovered when alarms are triggered on the monitor or anesthesia machine or when vital signs change. Nowadays, tracheal tubes equipped with cameras at the tip are used clinically [12, 13], allowing anesthesiologists to perform intubation and monitor the position of the tube with real-time images from the

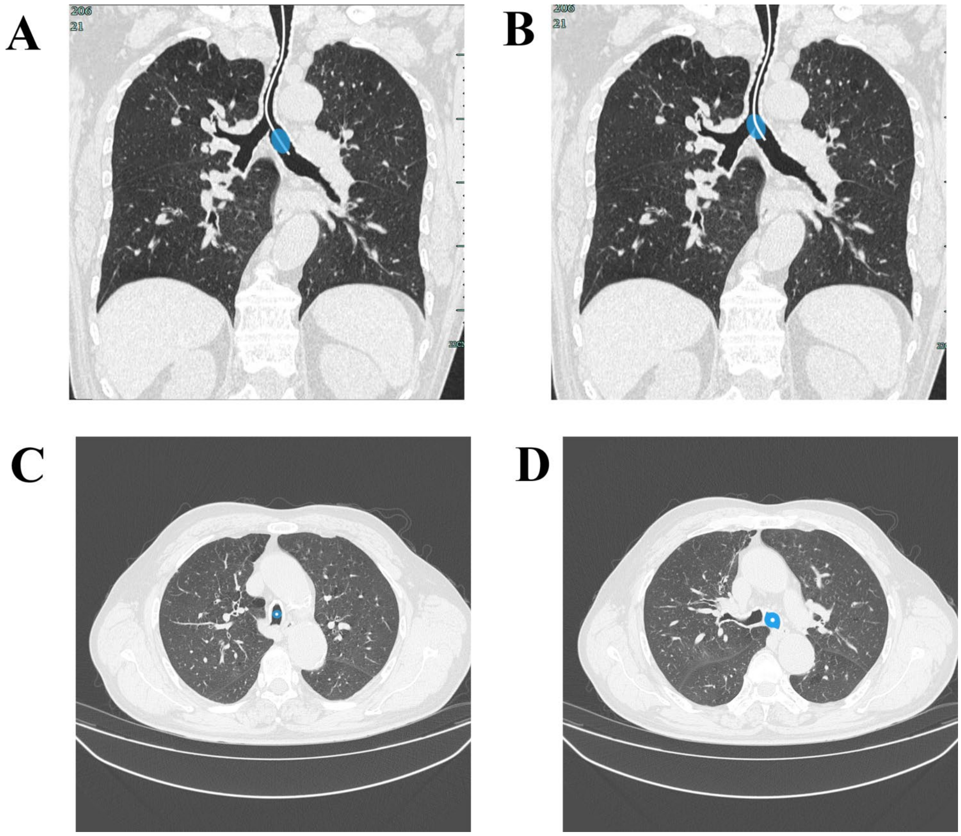

Fig. 3 **A** The schematic image of the initial appropriate position of the BB; **B** The schematic image of the balloon backed out of the bronchus; **C** The schematic image of the balloon formed an "incomplete airway obstruction"; **D** The schematic image of the balloon not completely backed out from the bronchus

camera, which is more convenient than FOB. However, because of the higher cost, they have not yet been widely used in clinical practice.

Conclusion

This report highlights the importance of previewing the chest CT scans and assessing the airway anatomy before surgery. Three-dimensional reconstruction of the airway can display the airway structure in an intuitive manner and simultaneously provide meaningful information for formulating systematic airway plans. In patients with existing tracheobronchial anatomy, the use of an SLT combined with a BB may be a choice. Notably, it should be high alert to balloon dislodgement or herniation, which causes a cardiopulmonary crisis.

Abbreviations

OLV one-lung ventilation
DLT double-lumen tube
BB bronchial blocker
SLT single-lumen tube
CT computed tomography
FOB fiberoptic bronchoscopy

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Author contributions

SQL collected all the patient initial data and drafted the manuscript, JZM completed the anesthesia management. All authors gave their comments on the article and approved the final version.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Shaoxing People's Hospital. This patient had signed the informed consent for this anesthesia procedure.

Consent for publication

Written informed consent was obtained from the patient for publication of this article and any accompanying images.

Competing interests

The authors declare no competing interests.

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