

# Difficult Establishment of One-Lung Ventilation Due to Preoperatively Undiagnosed Tracheal Bronchus and Collateral Respiratory Pathway in a Patient with Situs Inversus Totalis

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**ABSTRACT:** Secure one-lung ventilation (OLV) must be guaranteed during thoracoscopic surgery, and special attention is required for patients with central airway anomalies. A 72-year-old man with situs inversus totalis was scheduled for pleural biopsy for diagnosis of the pleural effusion etiology. We experienced difficult right bronchial intubation using a left-sided double-lumen tube due to subglottic resistance caused by tracheal deviation. Six months later, partial resection of the left lower lung lobe was scheduled under the diagnosis of adenocarcinoma. This time, we chose combined use of a single-lumen tube and a bronchial blocker; however, due to a tracheal bronchus and collateral respiratory pathways, which were preoperatively undiagnosed and incidentally found during the surgery, we could not successfully establish OLV. Based on our experience with this patient, we emphasize the importance of careful assessment of the tracheobronchial tree in patients with central airway anomalies who undergo surgery requiring OLV.

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**KEYWORDS:** one-lung ventilation, situs inversus totalis, tracheal bronchus, collateral respiratory pathways

## Introduction

Secure one-lung ventilation (OLV) must be guaranteed to prevent adverse events associated with thoracoscopic surgery. Special attention is required in the airway management of patients with central airway anomalies who undergo surgery requiring OLV. Situs inversus (SI) totalis is a rare disorder characterized by a full mirror image arrangement of thoracic and abdominal viscera; establish-

ment of OLV in patients with this disorder is challenging.<sup>1-3)</sup> Tracheal bronchus is the most common central airway anomaly, and is known to complicate airway management.<sup>4)</sup> Here, we report failure of OLV with combined use of a single-lumen tube (SLT) and a bronchial blocker due to a preoperatively undiagnosed tracheal bronchus and collateral respiratory pathways in a patient with SI totalis.

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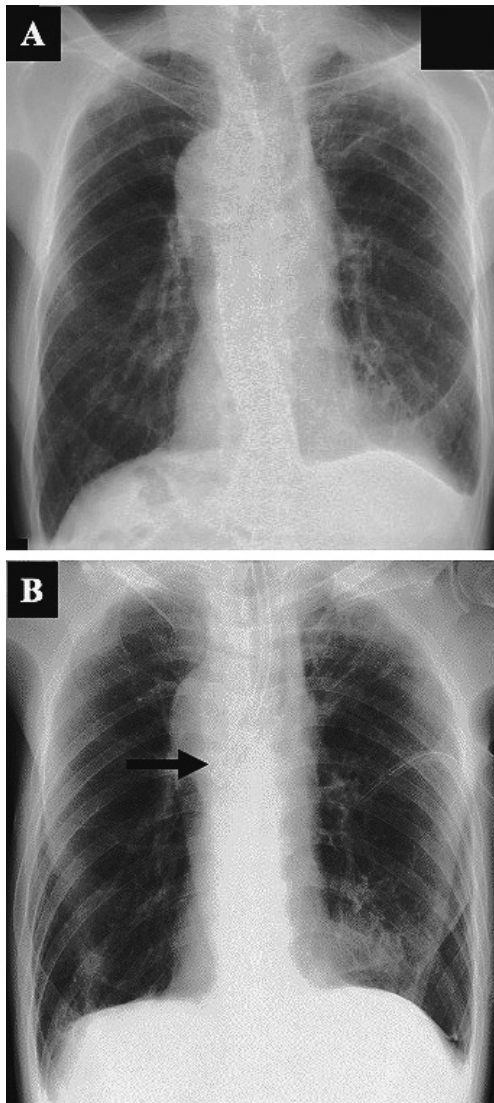


Fig. 1 Imaging findings associated with the first surgery. (A) Preoperative X-ray demonstrated situs inversus totalis and tracheal deviation. (B) Postoperative X-ray demonstrated that the bronchial lumen of the DLT (arrow) was appropriately positioned in the right main bronchus.

## Case Report

### First surgery

A 72-year-old man was referred to our hospital with common cold-like symptoms and left-sided pleural effusion. Hyaluronic acid concentration in the aspirated pleural effusion was 113,000 ng/mL and pleural effusion cytology was class IIIa. As no evidence of malignancy was detected by transbronchial lung biopsy, thoracoscopic pleural biopsy was scheduled for a definitive diagnosis. Preopera-

tive chest X-ray demonstrated SI totalis and tracheal deviation (Fig. 1A). Preoperative computed tomography (CT) demonstrated atelectasis in the left lower lung lobe and interstitial pneumonia, although the tracheal bronchus was overlooked (image not shown). We decided to perform right bronchial intubation using a 37-Fr, left-sided double-lumen tube (DLT: Shiley™ endobronchial tube; Covidien Japan, Tokyo, Japan) during anesthetic management for the first surgery (i.e., the thoracoscopic pleural biopsy).

After preoxygenation with pure oxygen, general anesthesia was induced and maintained with propofol, remifentanyl, fentanyl, and rocuronium. Propofol was administered using the target-controlled infusion method with an effect site concentration of 2.5-3  $\mu\text{g/mL}$ . Remifentanyl was also administered as a continuous infusion at the rate of 0.05-0.3  $\mu\text{g/kg/min}$ . Rocuronium was administered intermittently under neuromuscular monitoring. A Bispectral Index monitor (Aspect Medical Systems, Inc., Norwood, MA, USA) was used for anesthetic depth monitoring.

After induction of general anesthesia, we advanced the DLT with clockwise rotation in a blind manner, and encountered strong subglottic resistance, probably due to tracheal deviation. Thus, we decided to intubate the DLT under the guide of a fiberoptic bronchoscope (FOB). First, we inserted the tip of the FOB to the right bronchus, and tried to advance the DLT. But we encountered strong subglottic resistance, again. Second, we positioned the tip of the FOB at a position slightly protruding from the distal end of the bronchial-lumen of the DLT, and gradually advanced the DLT with maintaining the visualization of the trachea and right bronchus. This procedure was difficult due to the tracheal deviation; however, we eventually succeeded in placing the bronchial lumen of the DLT in the right main bronchus. Postoperative X-ray demonstrated that the bronchial lumen of the DLT was appropriately positioned in the right main bronchus (Fig. 1B).

Due to pleural adhesion of the left upper lung lobe, we could not evaluate the degree of deflation of the left upper lung lobe. However, the left lower lung lobe was completely deflated. Pleural biopsy was successfully performed. The inspired oxygen fraction ( $\text{FiO}_2$ ) during OLV was 0.74. Throughout the anesthetic management, oxygen saturation of the peripheral artery ( $\text{SpO}_2$ ) was maintained above 99%.

The patient's trachea was extubated immediately after surgery. His postoperative course following the first surgery was uneventful and he was discharged on the 4th

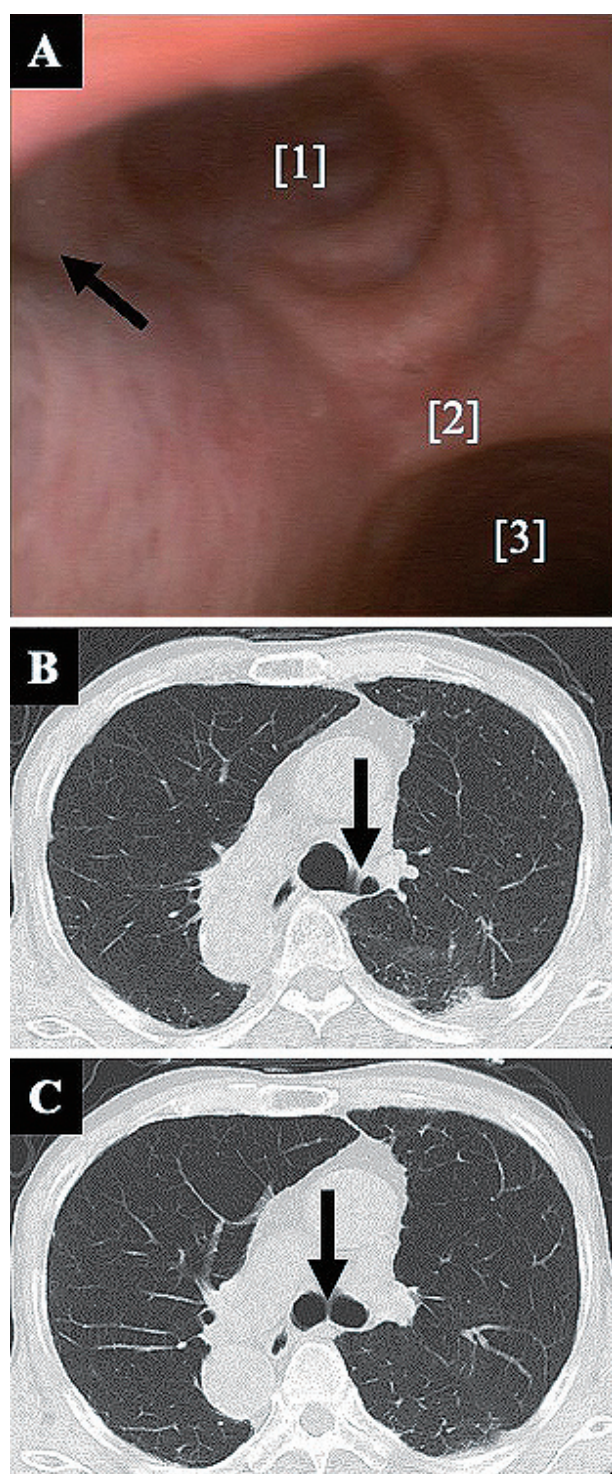


Fig. 2 Imaging findings associated with the second surgery. (A) Bronchoscopy demonstrated a type-III tracheal bronchus (arrow): [1] intermediate bronchial trunk, [2] carina, [3] right main bronchus. This image was captured in the right lateral position. (B) A type-III tracheal bronchus (arrow) was retrospectively confirmed. (C) The carina (arrow) was seen 1 cm caudal to the origin of the left upper lobe bronchus.

postoperative day. The pathological diagnosis was fibrous pleuritis with no malignancy.

### Second surgery

Six months after the thoracoscopic pleural biopsy, chest CT indicated a tumor in the left lower lung lobe. Interstitial pneumonia was simultaneously pointed out for the first time. Transbronchial lung biopsy provided evidence of adenocarcinoma, and thoracoscopic partial resection of the left lower lung lobe was scheduled. Again, we overlooked the tracheal bronchus preoperatively. As we had previously experienced difficult intubation using a DLT due to the tracheal deviation in this patient, and complete deflation of the left upper lung lobe could not be expected due to pleural adhesion, we chose to combine an 8.5-mm internal diameter SLT (Shiley™ reinforced endotracheal tube; Covidien Japan) and a bronchial blocker (COOPDECH® Endobronchial Blocker Tube; Daiken Medical, Osaka, Japan) for the establishment of OLV in the second surgery.

An epidural catheter was placed at the Th8/9 intervertebral space. After preoxygenation with oxygen ( $\text{FiO}_2 = 0.47$ ), general anesthesia was induced and maintained with propofol, fentanyl, and rocuronium. During the second surgery, we avoided the administration of high oxygen concentration due to interstitial pneumonia. Propofol was administered using target-controlled infusion with the effect site concentration set at  $3 \mu\text{g/mL}$ . Fentanyl and rocuronium were intermittently administered. As in the anesthetic management of the first surgery, we applied neuromuscular monitoring and anesthetic depth monitoring.

Following tracheal intubation using the SLT, we advanced the bronchial blocker to the left bronchus (i.e., the anatomically right bronchus) under FOB guidance and estimated the position of the blocker to be appropriate. After the start of surgery, however, thoracoscopic imaging demonstrated that the left lower lung lobe was insufficiently deflated and slightly ventilated. Hence, we advanced the blocker to the intermediate bronchial trunk. However, despite complete blockade, the left lower lung lobe was still slightly ventilated. Therefore, we advanced the SLT to the right main bronchus under FOB guidance. During this procedure, we noticed the presence of a type-III tracheal bronchus (Fig. 2A).<sup>4)</sup> Eventually, complete deflation of the left lung was achieved, and the surgery was successfully completed. Retrospective inspection of chest CT images confirmed the left upper lobe bronchus arising from the trachea just proximal to the carina (Fig. 2B). The carina



was located 1 cm caudal to the origin of the left upper lobe bronchus (Fig. 2C). FiO<sub>2</sub> during OLV was 0.34 and SpO<sub>2</sub> was maintained between 93% and 97%. The patient's trachea was extubated immediately after surgery. His postoperative course following the second surgery was uneventful and he was discharged on the 6th postoperative day. The pathological diagnosis was primary lung adenocarcinoma.

## Discussion

Patients with SI are often asymptomatic unless they have Kartagener's syndrome.<sup>1,2)</sup> SI is divided into SI totalis and SI with levocardia.<sup>5)</sup> Although SI totalis is more common than SI with levocardia,<sup>5)</sup> it is still rare and occurs in only 0.003%-0.024% of the population.<sup>1,3)</sup>

There are two standard methods to establish OLV as follows: application of a DLT and combined use of an SLT and a bronchial blocker. Either right bronchial intubation using a left-sided DLT or left bronchial intubation using a right-sided DLT is recommended in patients with SI,<sup>1)</sup> and assessment of central airway anatomy using a FOB prior to appropriate DLT selection is recommended.<sup>3)</sup> However, OLV with a right-sided DLT can cause obstruction of the upper lobe bronchus.<sup>6)</sup> We thus chose right bronchial intubation using a left-sided DLT in the first surgery (i.e., the thoroscopic pleural biopsy), although we experienced difficulty in intubation.

Ho et al. recommended combined use of a SLT and a bronchial blocker for OLV in patients with SI.<sup>1)</sup> Although placement of a bronchial blocker in the anatomically right main bronchus (i.e., the left main bronchus in patients with SI) obstructs the left upper lobe bronchus, complete deflation of the left upper lung lobe in this patient could not be expected due to pleural adhesion. Preoperatively, we estimated that the surgical procedures required for the second surgery (i.e., thoroscopic partial resection of the left lower lung lobe) could be completed even with insufficient deflation of the left upper lung lobe. Therefore, we chose combined use of a SLT and a bronchial blocker in the second surgery. However, OLV could not be established due to the presence of a preoperatively undiagnosed tracheal bronchus and collateral respiratory pathways.

Tracheal bronchus is the commonest central airway anomaly and is present in 0.1%-3% of the population.<sup>4)</sup> There are three types of tracheal bronchus, all of which make airway management difficult, particularly when OLV is required.<sup>4)</sup> In patients with tracheal bronchus,

when deflation of the anatomical left lung lobes is required, the combined use of a SLT with a bronchial blocker may be suitable for the establishment of OLV because it is not easy to place the DLT in the appropriate position.<sup>4)</sup> In addition to the choice of the methods for OLV, hypoxia associated with malposition of a tube (i.e., a DLT or a SLT) and a bronchial blocker should be cared. As we overlooked tracheal bronchus in this patient prior to the second surgery, we chose the combined use of a SLT with a bronchial blocker for deflation of the left lung (i.e., the anatomical right lung). We considered that morphological changes associated with tracheal deviation made preoperative detection of the type-III tracheal bronchus difficult in this patient. It is impossible to block both tracheal bronchus and the intermediate bronchial trunk using a single bronchial blocker. After noticing that the lower lung lobe was insufficiently deflated and slightly ventilated, we advanced the bronchial blocker to the intermediate bronchial trunk for deflation of the middle and lower lung lobes. However, we could not establish complete deflation of the lower lung lobe, probably due to collateral respiratory pathways.

Ventilation of the lung distal to the complete obstruction site can be preserved by collateral respiratory pathways.<sup>7)</sup> Slight ventilation of the left lower lung lobe after complete blockade of the intermediate bronchial trunk strongly suggested collateral respiratory pathways in this patient.

## Conclusion

We reported a rare case of SI totalis complicated with tracheal bronchus. Coexistence of these two anomalies along with collateral respiratory pathways made establishment of OLV difficult. Strategic planning for OLV based on careful preoperative assessment of imaging findings is required in patients with central airway anomalies.

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**Authors' contribution:** KK, RK, AS, and TK made clinical decisions. KK drafted the manuscript and prepared the figures. RK, MU, AS, and HK helped edit the manuscript. TK supervised the management of this case and edited the manuscript. All authors read and approved the final manuscript.

**Ethics statement:** Not applicable.

**Conflicts of interest:** None declared.

**Consent for publication:** Written informed consent was obtained from the patient for publication of this case report and all accompanying images.

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