Case Report

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Successful one-lung ventilation by blocking the right intermediate bronchus in a 7-year-old child: a case report

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Abstract

A 7-year-old child underwent surgical excision of a benign mesothelioma of the pleura near the right lower lung. Although insertion of a wire-reinforced endotracheal tube through the left main bronchus was attempted for one-lung ventilation to secure the surgical field of view, the attempt failed. Therefore, an endotracheal tube was inserted into the trachea, and an Arndt endobronchial blocker (Cook Medical, Bloomington, IN, USA) was placed in the right intermediate bronchus under bronchoscopic guidance to selectively block the right lower and middle lobes. The surgery was performed while ventilating the right upper lobe and left lung, and no specific intraoperative adverse events occurred.

Keywords

Arndt endobronchial blocker, lateral decubitus position, one-lung ventilation, pediatrics, thoracic surgery, mesothelioma

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Introduction

Children are more likely than adults to develop hypoxia when they are under general anesthesia because they have a smaller

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body size and consume more oxygen per kg of body weight.[1,2] In addition, when children are in the lateral decubitus position during anesthesia, they experience difficulty in ventilation.[3] For these reasons, maintenance of one-lung ventilation while performing thoracic surgery is difficult in children under anesthesia. Furthermore, a double-lumen endotracheal tube (DLT), which is used to maintain one-lung ventilation, is too large for use in a 7-year-old child.[4] We herein describe a case in which after failing to place a wire-reinforced endotracheal tube in the left main bronchus, we placed an Arndt endobronchial blocker (Cook Medical, Bloomington, IN, USA) in the right intermediate bronchus and effectively performed one-lung ventilation. The present case report addresses the physiological characteristics of a child under anesthesia and the methods for inducing one-lung ventilation.

Case report

A 7-year-old girl (height, 124 cm; weight, 26 kg) was diagnosed with a benign mesothelioma of the pleura and subsequently underwent surgical excision. Except for a history of treatment for influenza 2 years earlier, she had no other specific disease. She was admitted to a clinic with the chief complaint of right chest pain during coughing that had begun 1 week earlier. Based on suspicion of a pleural mass on chest radiography, she was transferred to our hospital (Figure 1). Chest computed tomography performed at our hospital revealed a non-enhanced fat-density lesion of approximately 4 cm in the area near the 7th to 9th right ribs. Surgical excision was planned, and preoperative laboratory studies showed no abnormal findings. Electrocardiography results showed normal sinus rhythm, and her vital signs were stable with blood

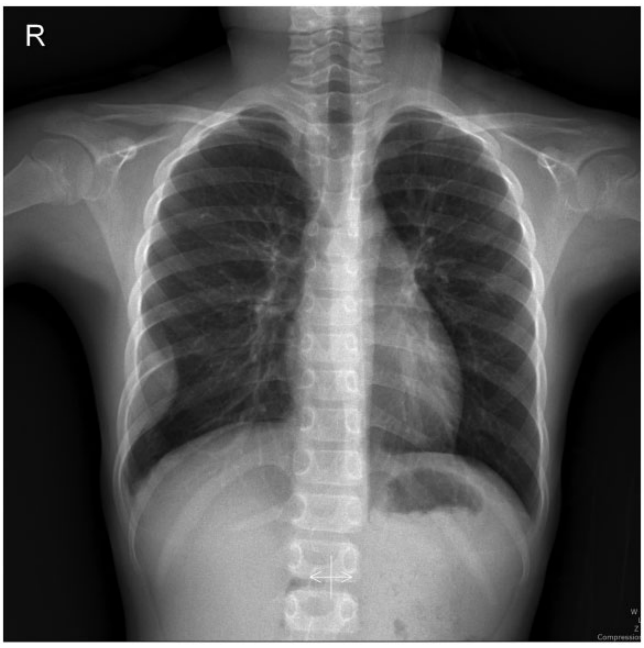

Figure 1. Chest radiograph shows a pleural mass in the right lower lung field.

pressure of 90/50 mmHg, heart rate of 138 beats/min, body temperature of 36.5°C, and respiratory rate of 22 breaths/min.

She entered the anesthesia waiting room with her guardian, and she was moved to the operating room after intravenous sedation using 50 mg of ketamine. Noninvasive blood pressure monitoring equipment, electrocardiography, and pulse oximetry were used to monitor her vital signs, and anesthesia was induced without complications. A neuromuscular block was performed using intravenous injection of 50 mg of succinylcholine, and tracheal intubation was attempted. An attempt was made to place a 5.5-mm wire-reinforced endotracheal tube into the left main bronchus using a curved direct #2 laryngoscope blade, but the attempt was unsuccessful. A 3.1-mm-diameter flexible bronchoscope (LF-DP; Olympus, Tokyo, Japan) was used to guide the tube, but the approach was unsuccessful. Subsequently, 150 mg of thiopental and 2 mg of vecuronium were administered because the patient required additional sedation, after which ventilation was performed by placing a 5.5-mm endotracheal tube in the trachea. Because the initially planned method was unsuccessful, a decision was made to induce one-lung ventilation using a bronchial blocker. A flexible bronchoscope was used to place an Arndt endobronchial blocker (7.0 Fr, 65 cm long) into the right main bronchus, and the blocker was eventually advanced into the right intermediate bronchus after ensuring that it had passed through the right upper lobe bronchus (Figure 2). After auscultation to confirm that lung sounds were absent in the right lower lung field, the blocker was fixed. Anesthesia was maintained using 2.5–3.5 vol% sevoflurane, 0.9 L/min of oxygen, and 2.1 L/min of air. The patient was switched to the left lateral decubitus position for video-assisted thoracoscopic surgery. Ventilation of the right

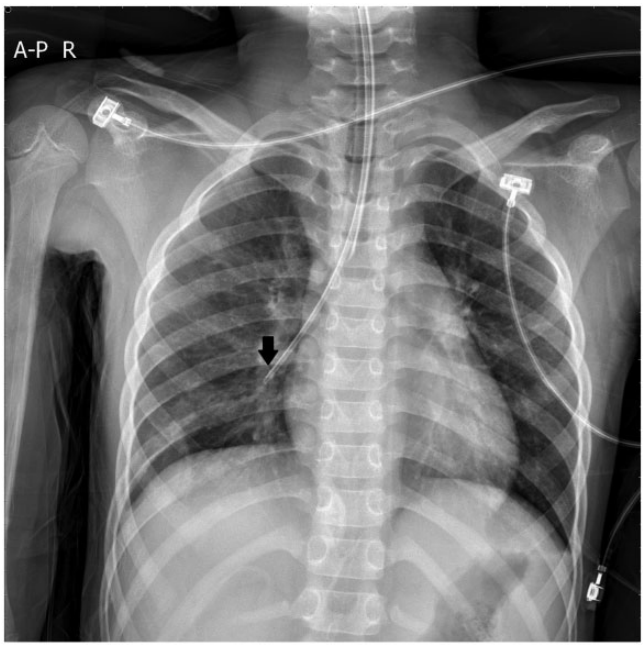

Figure 2. Tip of Arndt endobronchial blocker was placed in the right intermediate bronchus (arrow).

upper lobe did not interfere with the surgical field of view, and no intraoperative adverse events occurred. After the surgery, 0.2 mg of glycopyrrolate and 5 mg of pyridostigmine were administered to reverse the neuromuscular block. Because tachycardia of >160 beats/min occurred during emergence from anesthesia, 7 mg of esmolol was administered intravenously. After monitoring the patient for about 1 hour in the recovery room, she had exhibited no abnormalities and was therefore transferred to the general ward.

This study was approved by the institutional review board of Eulji University Medical Center and was performed in compliance with the EQUATOR Network guidelines. Written informed consent for publication was obtained from the patient's parents.

Discussion

The lateral decubitus position and one-lung ventilation are necessary to ensure a maximum field of view and appropriate operating environment during thoracic surgery. However, when anesthetized patients undergo mechanical ventilation in the lateral decubitus position, they become vulnerable to respiratory complications because of increased ventilation/perfusion (V/Q) mismatch.[5] Other causes that further elevate V/Q mismatch are less blood flow into the upper lungs because of gravity and an increase in the alveolar dead space.[6,7] Moreover, when positive ventilation is applied while the abdominal cavity components are pressing down on the dependent hemidiaphragm, compliance in the upper lung increases, further increasing V/Q mismatch.[6,8] Furthermore, the dependent lung becomes compressed in the lateral decubitus position, which may result in a higher frequency of atelectasis, and the operative lung may collapse from one-lung ventilation or from being manipulated during surgery.[6]

Children have smaller body frames than adults, and their chests can be easily deformed even with little compression. Consequently, their functional residual capacity may be reduced to a level similar to the residual volume in the lateral decubitus position, and airway closure in the dependent lung may also occur.[2,6] Moreover, because of children's small body size, it is difficult to achieve a hydrostatic pressure gradient effect in the dependent and nondependent lungs.[2] Finally, children require a large volume of oxygen. Oxygen consumption in adults is 2 to 3 mL/kg/min, whereas children consume 6 to 8 mL/kg/min.[1] Therefore, when children are placed under one-lung ventilation in the lateral decubitus position, they are vulnerable to hypoxemia.[3]

For one-lung ventilation, it is common practice to use a DLT, which ventilates the main bronchus on both sides by the respective lumen. However, even the smallest DLT has a diameter that is too large for use in children under 8 years old.[4,9] Another method for one-lung ventilation is the use of a bronchial blocker in the main bronchus. After positioning a one-lumen endotracheal tube at the trachea, a bronchial blocker can be inserted through the tube to block the main bronchus. Another method involves unilateral insertion of a one-lumen endotracheal tube into the main bronchus. Anatomically, the angulation of the right main bronchus is less acute than that of the left main bronchus, which makes placement in the right main bronchus technically easier. For placement in the left main bronchus, turning the tube to the left when the tip of the tube approaches the trachea and turning the patient's head to the right can be helpful for intubation.[2] Although this is a simple method that does not require other instruments, placing the one-lumen endotracheal tube in the main bronchus does not allow

the opposite lung to be viewed with a bronchoscope, and suction cannot be performed. In the event of infection or bleeding, the normal lung may be affected as well.[9,10]

In the present case, we decided to insert a one-lumen endotracheal tube into the left main bronchus because this is the simplest method and the operation was expected to be short. An attempt was made to insert the one-lumen endotracheal tube into the child's left main bronchus using a flexible bronchoscope. However, the attempt failed because of the angulation. Next, we attempted to use a bronchial blocker to induce one-lung ventilation. This method involved placing the endotracheal tube in the trachea, followed by advancing the Arndt endobronchial blocker, embolectomy catheters, and pulmonary artery catheter through the tube to reach the bronchus to be blocked and expanding the balloon to block that bronchus. This method has the advantages of allowing the lung to collapse by completely blocking the main bronchus and ensuring easy transition from one-lung to dual-lung ventilation.[8] However, if the bronchial blocker advances proximally when the patient's position is changed, it can block the trachea and interfere with ventilation; thus, it is better to deflate the balloon prior to the position change and advance the tube about 1 cm before fixation.[10] In the present case, the one-lumen tube was positioned at the trachea, and the Arndt endobronchial blocker was moved into the tube using the bronchoscope. Because the surgical site was in the right lower chest, we positioned the Arndt endobronchial blocker at the right intermediate bronchus after ensuring that the bronchoscope had moved past the right upper lobe bronchus. After confirming that the balloon of the Arndt endobronchial blocker was positioned at the right intermediate bronchus, we removed the bronchoscope (Figure 2). We confirmed the absence of

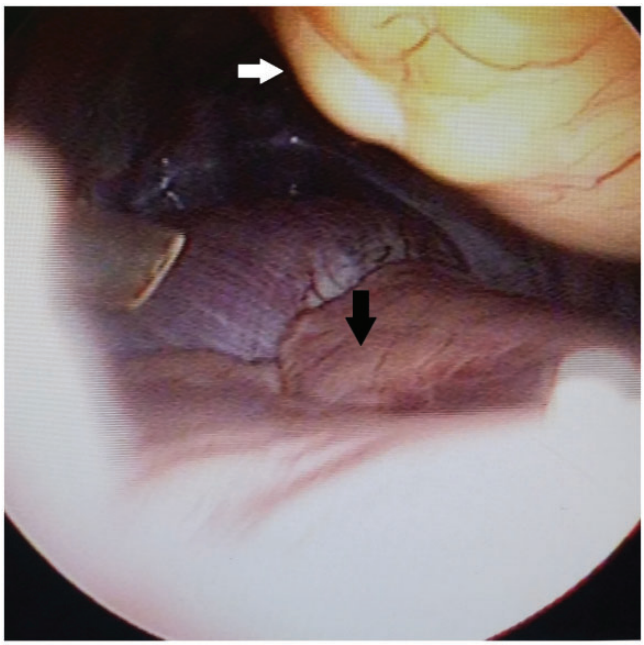

Figure 3. Thoracoscopy shows the pleural mass (white arrow) and the collapsed right lower lobe (black arrow).

respiratory sounds in the right lower lung field by auscultation. The surgical field of view was unobstructed with preservation of the right upper lobe function (Figure 3). This selective isolation of the right middle and lower lobes can be a good technique for one-lung ventilation in children, and it preserves the functional lobes as much as possible.

An increasing number of pediatric patients require one-lung ventilation during anesthesia. Accordingly, various methods have been attempted. Physiologically, children are more vulnerable to hypoxemia, and it is desirable to allow the non-operative lung to perform its normal role. Existing bronchial blockers that use one-lung ventilation block the main bronchus and thus completely prevent ventilation in one lung. In the present case, a bronchial blocker was placed in the right intermediate bronchus of a 7-year-old child. By selectively blocking the right middle and lower lobes, the function of the right upper lobe was preserved, minimizing the risk of hypoxemia and atelectasis. Limited resources are available in many centers; therefore, the existing materials should be identified and prepared, and several strategies should be applied to ensure optimal anesthesia.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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