J Anesth (2001) 15:57–59

Journal of
Anesthesia

One-lung ventilation with the Univent tube in a pediatric patient undergoing video-assisted thoracoscopic surgery

Masahiro Kanazawa, Haruo Fukuyama, Miyoko Kihara, Yoshio Kinefuchi, and Mamoru Takiguchi

Department of Anesthesiology, Tokai University School of Medicine, Boseidai, Isehara, Kanagawa 259-1193, Japan

Key words One lung ventilation · Univent tube · VATS · Video-assisted thoracoscopic surgery

Introduction

Recently, video-assisted thoracoscopic surgery (VATS) has become an increasingly adopted surgical procedure. VATS offers several benefits for the patient, but it requires one-lung ventilation (i.e., controlled collapsing of one lung) to provide a good surgical field. In most cases, VATS has been applied to adult patients. In the case reported, here we used VATS on a pediatric patient (an eight-year-old boy). Hypercapnia occurred during VATS, but we successfully performed one-lung anesthesia using a small Univent tube Fuji Systems, Japan.

Case report

An eight-year-old boy weighing 21 kg had previously undergone a bone marrow transplant for Fanconi anemia. Three months later, aspergillus pneumonitis was discovered in his right lung, where a cavity was observed by CT scan. The pneumonitis was not treatable by chemotherapy, and cavity resection surgery was scheduled. Preoperatively, the patient's platelet count was decreased, the prothrombin time was prolonged, and he was exhibiting cough and sputum production. VATS was selected because of its minimum postoperative influence on the patient. Furthermore, cavity resection would be the only surgical procedure required. In order to obtain a deflated lung for VATS, it was imperative to use an uncuffed Univent tube 8 mm in external diameter, because the patient's tracheal size was 10 mm, as observed from the preoperative chest X-ray (Fig. 1).

No premedication was given. Anesthesia was induced by injecting 60 mg of propofol, 25 μg of fentanyl, and 3 mg of vecuronium intravenously. A small, uncuffed Univent tube, 3.5 mm in internal diameter was the placed in the trachea (Fig. 2). After induction of general anesthesia, a blocker tube was advanced into the right main bronchus under bronchoscopy, and a blocker balloon was positioned in place to deflate the right lung. A 22-gauge catheter was placed in the left radial artery. General anesthesia was maintained with 40%–100% oxygen and sevoflurane; occasionally, nitrous oxide and intravenous fentanyl (total, 200 μg) were administered.

After pressure controlled ventilation (PCV) had been initiated, arterial blood gas analysis under bilateral ventilation showed a pH of 7.385, $PaCO_2$ of 43.7 mmHg, and PaO_2 of 158 mmHg, with a peak airway pressure of 15 cmH_2O, FiO_2 of 0.4, and ventilation frequency of $10 \cdot min^{-1}$. By inflating the blocker cuff, we could block the right bronchus. However, a leak of anesthetic gas around the tracheal tube became obvious at an airway pressure of 18 cmH_2O, causing difficulty in maintaining the static airway pressure of 20 cmH_2O. We expected that the proper levels of $PaCO_2$ and PaO_2 could be maintained during one lung anesthesia by increasing the frequency of ventilation.

After the posture of the patient had been changed to the lateral position, one-lung anesthesia was initiated, and the fully deflated right lung was provided with a blocker cuff of 2.5 ml. However, the leak increased beyond expectation, and the patient developed hypercapnia. The results of arterial blood analysis were pH 7.291, PCO_2 66.3 mmHg, and PO_2 107 mmHg, with PCV peak airway pressure 20 cmH_2O, ventilation frequency $15 \cdot min^{-1}$, and 100% oxygen. Gauze was packed into the

Address correspondence to: M. Kanazawa
Received: November 5, 1999 / Accepted: August 22, 2000

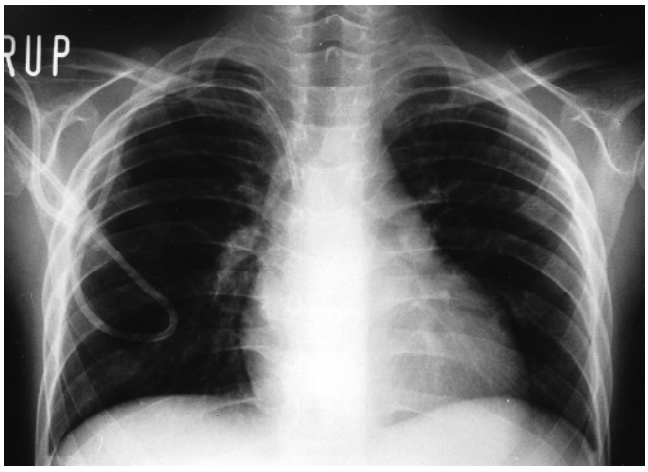

Fig. 1. Photograph demonstrating the tracheal diameter of 10 mm. That prohibited us from using a cuffed Univent tube

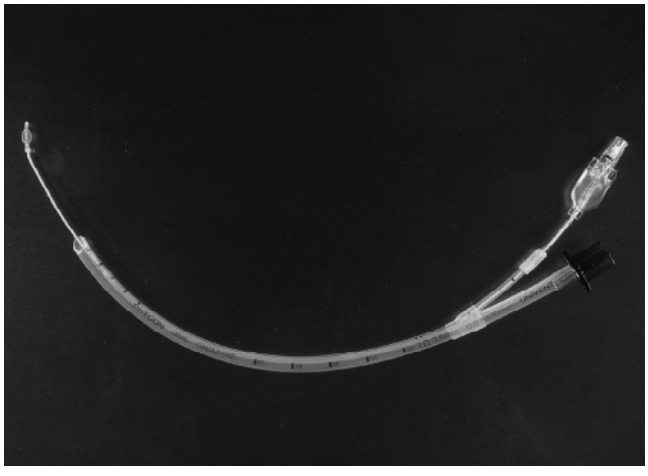

Fig. 2. Uncuffed Univent tube of 3.5 mm internal diameter and 8 mm external diameter. No cuffed Univent tube was commercially available for pediatric use when our patient was being treated

patient's pharynx to decrease the leak, and the frequency of ventilation was increased to $20 \cdot min^{-1}$. Nevertheless, hypercapnia did not improve with maximum PCO_2 of 94.3 mmHg.

Middle lobectomy was performed because of severe inflammatory change in the middle lobe. The duration of the operation was 3 h. The one-lung ventilation time was 2 h 30 min. A small atelectasis in the lower lobe was observed bilaterally in the postoperative chest X-ray. However, the patient had a good emergence with SpO2 of 97% in 40% oxygen. Therefore, the patient was extubated in the operating room without trouble and was admitted into the intensive care unit. The atelectasis showed marked improvement by the morning following surgery.

Discussion

Hammer et al. reported one-lung anesthesia using a cuffed Univent tube on a pediatric patient (a 10-year-old girl weighing 40 kg) undergoing VATS [1]. The internal diameter of their patient's trachea was 13 mm, whereas that of our patient was 10 mm. The difference of 3 mm made the selection of an endotracheal tube more difficult. We determined that the cuffed Univent tube used in Hammer's patient (with internal and external diameters of 4.5 and 9 mm, respectively) could not be used in our patient. Instead, a smaller uncuffed Univent tube with internal and external diameters of 3.5 and 8 mm, respectively, was used. We could not help using an uncuffed tube, even though we were greatly concerned about the possibility of hypercapnia occurring as a result.

Prior to performing the VATS, it is necessary to obtain a fully deflated lung. Four methods were available to obtain a fully deflated lung in this patient [1–5]: (1) left bronchial intubation with a normal endotracheal tube, (2) double-lumen endotracheal tube (DLT), (3) right bronchus blockade with a Fogarty catheter, and (4) uncuffed Univent tube. In method (1), repeated collapsing and expansion of the right lung with bronchial intubation causes too many complications. In method (2), no commercial DLT fitting our patient's trachea size was available. In method (3), maintaining the position of the balloon tip and the shaft of the catheter would be difficult, since the bifurcation of the right upper bronchus was located at a more proximal site than a normal one and the patient's trachea had an internal diameter of 10 mm. These points were observed in the preoperative chest X-ray and CT scan. In addition, we had achieved successful results using the Univent tube to provide good property concerning balloon holding with adult patients on a daily basis. This encouraged us to believe that a similar result could be expected in this case as well. Based on these considerations, we decided to use a Univent tube of 3.5-mm internal diameter. Since the blocker shaft of the 3.5-mm internal diameter Univent tube was not equipped with an inner lumen, suctioning sputum or blood through a lumen from the lung's surgical field was not possible. However, the blocker balloon can prevent secretion from the surgical field to the ventilated lung in the lateral position. As a result, the Univent tube worked to provide a fully deflated lung, and the VATS procedure went smoothly. However, during one-lung anesthesia, the patient exhibited hypercapnia. We assumed this was brought about by the leak of ventilation related to using the uncuffed tube. Since hypoventilation was not observed during bilateral ventilation, changing the patient to a lateral position and initiating one-lung ventilation might have caused hypoventilation because of the

increase of the leak associated with the decrease of lung compliance. Since the minute volume during one-lung ventilation should be essentially the same as that during bilateral ventilation, peak airway pressure should be raised to obtain the same volume, after initiating one-lung ventilation. However, it was difficult to raise the peak airway pressure above 20 cmH_2O in the present case. Even though the ventilation frequency was increased from 10 to 25 $\cdot min^{-1}$, sufficient minute volume could not be obtained.

Care should be take toward air trapping resulting from the use of too small an endotracheal tube. However, in this case, since atelectasis was observed in the ventilated lung after the operation, we concluded that air trapping did not occur, but rather that hypercapnia was caused by the leak.

Because of the patient's tracheal size, the use of the uncuffed Univent tube was unavoidable. Generally, one-lung ventilation on a pediatric patient with an uncuffed tube will cause hypoventilation, especially in the lateral position. To avoid hypoventilation, the use of the cuffed tube may be recommended to secure proper minute volume during one-lung anesthesia. However, the cuffed tube has the disadvantages of causing ischemic damage and edema of the tracheal wall in pediatric patients. If these complications are to be avoided, hypercapnia caused by using an uncuffed tube must be accepted within certain guidelines. There are a few reports concerning permissive hypercapnia [6,7]. However, points concerning the upper or lower limits of PCO_2 or pH, especially in pediatric patients, are still unclear.

In conclusion, we allowed hypercapnia over 80 mmHg of PCO_2 to occur because we had to use the uncuffed, small Univent tube in a pediatric patient undergoing VATS. However, we were able to provide sufficient oxygenation and controlled surgical field without complications due to hypercapnia.

References

1. Hammer GB, Brodsky JB, Redpath JH, Cannon WB (1998) The Univent tube for single-lung ventilation in pediatric patients. Pediatr Anesth 8:55–57
2. Rowe R, Andropoulos D, Heard M, Johnson K, DeCampli W, Idowu O (1994) Anesthetic management of pediatric patients undergoing thoracoscopy. J Cardiothorac Vasc Anesth 8:563–566
3. Mihalka J, Burrows FA, Burke RP, Javorski JJ (1994) One-lung ventilation during video-assisted thoracoscopic ligation of a thoracic duct in a three-year-old child. J Cardiothorac Vasc Anesth 8:559–562
4. Murqlidhar K, Prasad SD (1997) Technique for one-lung ventilation during video-assisted thoracoscopic surgical interruption of patent ductus arteriosus in children. J Thorac Cardiovasc Surg 114:300
5. Hammer GB, Manos SJ, Smith BM, Skarsgard ED, Brodsky JB (1996) Single-lung ventilation in pediatric patients. Anesthesiology 84:1503–1506
6. Amato MB, Barbas CS, Medeiros DM, Magaldi RB, Schettino GPP, Filho GL, Kairalla RA, Deheinzelin D, Munoz C, Oliveira R, Takagaki TY, Carvalho CRR (1988) Effect of protective ventilation strategy on mortality in the acute respiratory distress syndrome. N Engl J Med 338:347–354
7. Stewart TE, Meade MO, Cook DJ, Granton JT, Hodder RV, Lapinsky SE, Mazer CD, McLean RF, Rogovein TS, Schouten BD, Todd TRJ, Slutsky AS, for the Pressure- and Volume-Limited Ventilation Strategy Group (1988) Evaluation of a ventilation strategy to prevent barotrauma in patients at high risk for acute respiratory distress syndrome. N Engl J Med 338:355–361