J Anesth (1995) 9:380–382

Journal of
Anesthesia

Extracorporeal membrane oxygenation and tracheobronchial foreign body in an infant

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Key words: Tracheobronchial foreign body, Extracorporeal membrane oxygenation, Infant

Introduction

Inadvertent aspiration of foreign bodies into the tracheobronchial region occurs most often in children between 1 and 3 years old [1,2]. In the anesthetic management of removal of a tracheobronchial foreign body, difficulty arises when the ventilation route coexists with the surgical field in the narrow lumen of the tracheobronchial tree. It is most important to choose a ventilation technique which does not disturb the surgical procedure, because lethal asphyxia may occur if the foreign body occludes the trachea or main bronchus.

We report the successful use of extracorporeal membrane oxygenation (ECMO) for the removal of a tracheal foreign body which led to severe hypoxia.

Case report

A 1-year-old boy, weighing 10.1 kg, who had sudden but temporary cyanosis and weak respiratory sound of the right lung for 3 days, was transferred to the Department of Otolaryngology at our university hospital under the diagnosis of obstruction of the right main bronchus. On arrival, he was not cyanotic but the respiratory sound of the right lung field was not audible at all. A plain chest X-ray revealed slight inflammatory changes in the right lower lung field and the rightward deviation of the mediastinum at the inspiratory phase. No pulmonary atelectasis was detected. Computed tomography showed no sign of foreign bodies in the right main bronchus. Arterial blood gas analysis under room air was pH 7.395, partial arterial pressure of CO_2 ($Paco_2$) 35.3 mmHg, and O_2 (Pao_2) 86.5 mmHg, and arterial oxygen saturation (Sao_2) 96.3%. Routine laboratory tests, including blood chemistry and blood cell counts were within normal limits.

An emergency bronchofiberscopic examination to detect a foreign body was performed. Atropine sulfate (0.2 mg) was intravenously injected as an anesthetic premedication. The patient was anesthetized with an intravenous injection of 2 mg·kg^{-1} of sodium thiamylal. Then we assisted respiration with manual ventilation via an anesthetic mask. Thereafter, he was intubated with an endotracheal tube 4.5 mm inside diameter (i.d.) with the aid of additional thiamylal (2 mg·kg^{-1}) intravenously and vecuronium bromide (0.15 mg·kg^{-1}) intravenously. Electrocardiography (ECG) was carried out and pulse oximetry peripheral oxygen saturation, (Spo_2), end-expiratory carbon dioxide tension (P_{ETCO2}), osillometric blood pressure, and respiratory sounds of the left lung were monitored, the latter by a precordial stethoscope. Spo_2 before anesthetic induction was 92% (room air). Anesthesia was maintained with 1%–2% sevoflurane in oxygen, and the lungs were ventilated manually to keep Spo_2 between 97% and 100% and P_{ETCO2} between 35 and 45 mmHg.

The bronchofiberscopic examination disclosed a foreign body, a plastic cap, in the right main bronchus. The endotracheal tube was replaced with a rigid type ventilating bronchoscope (VBS) with a side port for ventilation. The patient was ventilated manually and Spo_2 was maintained at 98% or more. An attempt was made to remove the foreign body using an alligator forceps through the VBS, but the foreign body was too big to pass the vocal cords, and fell out of the forceps. Suddenly, manual ventilation became impossible and P_{ETCO2} was no longer detectable. We immediately removed the VBS, discontinued sevoflurane, and ventilated manu-

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Received for publication on January 9, 1995; accepted on June 27, 1995

ally via an anesthetic mask with pure oxygen. Spo_2 decreased to less than 30% and the heart rate (HR) decreased from 150 beats per minute (bpm) to 50 bpm. We intubated the trachea with an endotracheal tube 4.5 mm i.d. but the foreign body seemed to completely obstruct the trachea. We then pushed the foreign body further down the trachea by means of the endotracheal tube with a stylet. Ventilation suddenly became easy. Spo_2 returned to 99%, and HR increased to 130 bpm. However, there was alternating diminution of the breath sound on either side of the lung field. The foreign body was found riding on the bifurcation of the trachea by bronchofiberscopic examination. Tracheostomy was proposed but was rejected because of the possibility of difficult airway management.

We therefore decided to use ECMO to make removal of the foreign body easier while maintaining adequate oxygenation and ventilation. Informed consent was obtained from the parents prior to ECMO. The equipment for ECMO consisted of an oxygenator (MENOX EL-2000: membrane area = 0.4 m^2, Kuraray, Kurashiki, Japan), a centrifugal pump (HCV-11, Nikiso, Tokyo, Japan), and an ECMO circuit for children (Kuraray). The ECMO circuit was primed with 250 ml of lactated Ringer's solution containing 500 IU of heparin. After 100 $IU \cdot kg^{-1}$ of heparin was injected as a bolus, a 14 Fr catheter was inserted via the right internal jugular vein into the right atrium and a 12 Fr catheter was inserted into the right common carotid artery through the Gortex graft. Anesthesia was maintained with 0.5% sevoflurane in air and fentanyl (5 $\mu g \cdot kg^{-1}$). Activated clotting time (ACT) was monitored for control of blood coagulation. We started ECMO and maintained the centrifugal pump at 3900 rpm to obtain an output of 1–1.2 $l \cdot min^{-1}$ with a constant flow of oxygen at 1 $l \cdot min^{-1}$ (inspired oxygen fraction; FIO_2 = 0.5). During ECMO, the patient's hemodynamics were stable and Spo_2 was kept at 99% or more. ACT was maintained at over 200 s. When stable ECMO flow was obtained, arterial blood gas analysis was as follows: pH 7.49, Pa_{CO2} 33.0 mmHg, Pa_{O2} 204 mmHg, SaO_2 99.3%. Thereafter, we discontinued ventilation, and removal of the foreign body using the VBS was restarted. The foreign body, a plastic cap 6 mm in diameter and 6 mm in length, was successfully removed from the trachea using alligator forceps. The duration of ECMO was 39 min.

Postoperative bronchofiberscope and chest X-ray film revealed no abnormal findings. The patient was extubated 18 h after the operation and left the hospital 2 days later without sequela.

Discussion

In the anesthetic management of the removal of tracheobronchial foreign bodies in infants or children, it is most important to prevent hypoxia due to inadequate ventilation. Although the VBS has improved the safety of the operation [2], other methods should be considered in the event of insufficient ventilation through the side port of the VBS. These include high-frequency jet ventilation (HFJV) through the VBS [3] or the bronchofiberscope [4]. However, HFJV is as ineffective as VBS in case of complete tracheal occlusion. In the current situation, it was essential to push the foreign body into one of the main bronchi using an endotracheal tube with a stylet.

In the present case, we rapidly induced anesthesia with thiamylal and then confirmed the ability to manually ventilate because we believed that the foreign body was located in the right main bronchus from radiographic findings. The slow induction of anesthesia with inhalation anesthetics is generally used for the removal of a tracheobronchial foreign body in the case of sudden obtruction of the airway by the foreign body.

When the foreign body could not be removed during the first trial, we had four options: (1) use a Fogarty catheter, (2) tracheostomy, (3) open chest surgery and (4) ECMO. First, the use of a Forgarty catheter and tracheostomy were proposed but were rejected because of difficult airway management during the surgical procedure including critical sudden airway obstruction in our first attempt. Furthermore, we were not sure whether the foreign body could pass the tracheostomy stoma and we were concerned about postoperative tracheal stenosis in the infant. Second, open chest surgery is much more invasive than ECMO and would require more difficult respiratory management during anesthesia due to bronchostomy at the level of the main bronchi, including one-lung ventilation with or without HFJV. We, therefore, did not employ open chest surgery.

The use of ECMO in children has become popular recently because of improved safety and availability [5]. On the other hand, there are several physiologic complications in the use of ECMO. Of these complications, hemorrhage occurs most frequently (36%): intracranial hemorrhage (17%), surgical site (14%), and gastrointestinal hemorrhage (5%). The incidence of neurological complication is 27%: severe neuroimpairment (3%), seizures (20%), and others (4%), while that of pulmonary complications including pulmonary artery embolism by thrombus or air are less than 5% [6]. By utilizing ECMO, we could separate the ventilating route from the surgical field, thereby allowing sufficient time for removal of the foreign body. For removal of fragile foreign bodies such as a swollen peanut, the time for the procedure is an important consideration. To facilitate respiratory management during surgical procedure and to prevent life-threatening hypoxia, we decided to use

ECMO after we had explained to his parents the incidence of physiologic complications in the use of ECMO, his life-threatening hypoxic situation, and other options and obtained their informed consent. We have recognized that using ECMO for a healthy patient who may be put in a life-threatening situation is acceptable, as well as use for a patient suffering from severe respiratory failure.

In summary, we experienced a life-threatening hypoxic event during bronchoscopic removal of a foreign body in the trachea in a 1-year-old infant. The patient was successfully treated by clearing the occluded airway by pushing the foreign body down into a main bronchus followed by bronchoscopic removal under ECMO. ECMO may become a useful methods for tracheobronchial foreign body removal at hospitals that are accustomed to dealing with ECMO.

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