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Original Article

Anesthesia and ventilation for removal of airway foreign bodies in 35 infants

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Abstract: Objective: To explore the safety and effectiveness of modified adapter of Broncho-Cath™ Right double lumen tube in removal of tracheobronchial foreign bodies in children. Methods: General anesthesia was induced in 35 children with tracheobronchial foreign bodies. Then a laryngeal mask airway was implanted into each patient, and a modified adapter of Broncho-Cath TM Right double lumen tube was connected for intermittent positive-pressure ventilation. Results: 4, 21 and 10 children suffered from intratracheal foreign body, left main bronchial foreign body and right main endobronchial foreign body, respectively. Bronchofiberscope implantation was satisfactorily achieved in 32 children (91%), and success in bronchofiberscope was successfully implanted after adjustment in 3 children (9%). Compared to T_0, HR decreased at T_1 ($P < 0.05$) and significantly reduced at T_2, T_3 and T_4 ($P < 0.01$). MAP increased at T_1 and declined at T_3 ($P < 0.05$). PaO_2 rose significantly at T_1~T_5 ($P < 0.01$), and there were no statistical differences in $PaCO_2$ at different time points. Compared to ASA II patients, the incidences of severe hypoxemia, hypertension or hypotension were all higher, and the awakening time was longer in ASA III or IV patients ($P < 0.05$), and the bronchoscopy time was longer and the incidence of arrhythmia was significantly higher ($P < 0.01$). Conclusion: In removal of tracheobronchial foreign bodies in children, appropriately modified Broncho-Cath™ Right adapter and laryngeal mask airway after intravenous anesthesia for breathing control can improve the ventilation function and perioperative safety. Thereby, it is worthy of clinical application.

Keywords: Infant, anesthesia, ventilation

Introduction

Tracheobronchial foreign body in children is a common emergency in infants and has greater risk [1, 2]. The foreign body should be removed as early as possible once this disease is confirmed. In recent years, with the development of respiratory endoscopy technique, bronchofibroscopy has been widely used and has become the main means of removal of airway foreign body [3-5]. The severe conditions that the infants have small lumens and cannot provide active cooperation in surgical and anesthesia operations, and the airway needs to be shared in anesthesia, and surgical operations put forward a severe challenge to the clinical anesthesia. General anesthesia with reservation of spontaneous breathing is the preferred method in the past, but the depth of anesthesia is not easy to grasp. Meanwhile, intraoperative bucking aggravates the difficulty of the operation. Our study aims to seek a safe and effective anesthesia and ventilation management style by analyzing 35 children undergoing removal of tracheobronchial foreign bodies under a bronchofiberscope from May 2012 to April 2014.

Material and methods

General information

35 children with tracheobronchial foreign bodies (20 males and 15 females, aged 13 months to 8 years, body weight: 11-30 kg) were included, including 21 ASA II, 10 ASA III and 4 ASA IV patients. Before surgery, 11 children suffered from varying degrees of dyspnea, of whom, 5 cases were found to have serious airway obstruction and difficulty in lying on the back with PaO_2 < 60 mmHg by arterial blood gas analysis, and 3 cases $PaCO_2$ > 45 mmHg. 5 chil-

Table 1. Comparison of changes in respiration and circulation at different time points ($\bar{x} \pm s$, n=35)

Index	T_0	T_1	T_2	T_3	T_4	T_5
HR (beats/min)	132±12	115±9[a]	98±10[b]	102±7[b]	100±6[b]	125±11
MAP (mm Hg)	96.1±9.5	107.2±8.1[a]	90.7±6.2	89.9±6.0[a]	90.6±7.3	85.1±7.3[a]
PaO_2 (mm Hg)	67.4±9.1	166.5±11.3[b]	204.7±16.3[b]	198.8±12.0[b]	187.6±9.5[b]	81.5±10.3[b]
$PaCO_2$ (mm Hg)	38.8±5.2	33.1±6.0	36.8±5.5	32.1±6.2	36.9±5.6	34.7±3.6

Footnotes: [a]$P < 0.05$, [b]$P < 0.01$, compared to T_0.

dren were found to have atelectasis by chest X-ray examination. 12 patients suffered from varying degrees of gurgling with sputum by auscultation, including 3 cases with diffuse gurgling with sputum in both lungs. The microaspiration time was within 10 hours in 27 children, one week in 6 cases and two months in 2 cases. The foreign bodies included watermelon seed, sunflower seeds, peanuts, soybeans, etc. This study has been approved by the medical ethics committee of the hospital, and all the patients have signed informed consent form.

Anesthesia methods

The children need food and liquid fasting for 4-6 h. 0.02 mg/kg atropine or 0.01 mg/kg hyoscine were injected intramuscularly at 31 min prior to the operation. 3-5 mg/kg ketamine was intramuscularly injected before entering the room. 0. 3 mg/kg dexamethasone was infused intravenously into the body of the patients after they entered the room, and then routine monitoring of ECG, SPO_2 and NBP was performed. The adapter tip diameter of Broncho-Cath™ Right double-lumen endobronchial tube (Mallinckrodt Medical Corporation, Ireland) was expanded to the corresponding size with sharp blade in accordance with the diameter of selected bronchofiberscope. Midazolam 1 mg/kg, fentanyl 3~4 μg/kg, propofol 2~4 mg/kg and succinylcholine 2 mg/kg were administered for fast induction. Larynegeal mask airway was inserted (the larynegeal mask airway was selected in accordance with the body weight of the children: 2 for 10-20 kg, 2.5 for 20-30 kg) and the adapter was connected. Then manual intermittent positive pressure ventilation (IPPV) was performed with the frequency of 15-30 times/min, and the tidal volume was appropriate when the chest of the patients was lifted up moderately. The bronchofiberscope (Olympus, Japanese) was inserted from the prepared operational hole in the tip of the adapter. During the operation, propofol and succinylcholine were used for anesthesia and muscle relaxation maintenance, respectively. Bronchofiberscopy operations and removal of foreign bodies were completed by the same group of experienced surgeons.

Observed indexes

PaO_2 and $PaCO_2$ before induction (T_0) and at bronchofiberscope implantation (T_1) as well as at 5, 10 and 15 min after bronchofiberscope implantation (T_2, T_3 and T_4) and awakening (T_5) were measured by arterial blood gas analysis, and mean arterial pressure (MAP) and heart rate (HR) at each time point were recorded. The satisfactions for bronchofiberscopy implantation (successful bronchofiberscope implantation; satisfactory: no body movement and bucking, and clear glottis exposure; otherwise unsatisfactory) were recorded. The incidences of intraoperative severe hypoxemia (SPO_2 < 85% or SPO_2 < 90% for 30 s), hypercapnia, hypertension (20% higher than the baseline blood pressure) or hypotension (20% lower than the baseline blood pressure) in ASAII and ASAIII or IV patients were recorded. The bronchoscopy time, awakening time, arrhythmias and perioperative adverse reactions were recorded.

Statistical analysis

SPSS13.0 was used for analysis. Measurement data were expressed as mean ± SD. Paired *t* test was adopted for intra-group comparison, and x^2 test for comparison of count data. $P < 0.05$ was considered statistically significant.

Results

4, 21 and 10 children suffered from intratracheal foreign body, left main bronchial foreign body and right main endobronchial foreign body, respectively. Satisfactory bronchofiberscope implantation was achieved in 32 children (91%), and success in bronchofiberscope implantation after adjustment occurred in 3 children (9%). Rigid bronchoscope was adopted for removal of the foreign bodies in one patient

Table 2. Comparison of the time ($\bar{x} \pm s$) and perioperative complications between the two groups

Groups	Bronchoscopy time (min)	Awakening time (min)	Success number of broncho fiberscope implantation (n, %)	Intraoperative airway spasm [n, (%)]	Postoperative laryngeal edema [n, (%)]	Severe hypoxemia [n, (%)]	Hypertension or hypotension [n, (%)]	Arrhythmia [n, (%)]
ASA II (n=21)	17.2±8.4	10.3±3.6	19 (90%)	2 (10%)	0	1 (5%)	5 (24%)	7 (33%)
ASA III or IV (n=14)	25.7±6.5[b]	15.5±9.2[a]	13 (92%)	1 (5%)	1 (7%)	3 (21%)[a]	5 (36%)[a]	8 (57%)[b]

Footnotes: Compared to ASA II patients, [a]$P<0.05$, [b]$P<0.01$.

after failure in removal with a bronchofiberscope. No body movement, bucking, tooth mobility and falling out were observed in all the patients during bronchofiberscope implantation and operation.

Compared to T_0, HR decreased at T_1 ($P < 0.05$) and significantly reduced at T_2, T_3 and T_4 ($P < 0.01$). MAP increased at T_1 and declined at T_3 ($P < 0.05$). PaO_2 rose significantly at T_1~T_5 ($P < 0.01$), and there were not statistical differences in $PaCO_2$ at different time points between the two groups ($P > 0.05$) (See **Table 1**).

Compared to ASA II patients, intraoperative severe hypoxemia, hypertension or hypotension and awakening time in ASA III or IV patients were all higher ($P < 0.05$), and bronchoscopy time was obviously longer and the incidence of arrhythmia were significantly higher ($P < 0.01$). No statistical differences were found in the incidence of hypercapnia, intraoperative airway spasms and postoperative laryngeal edema between the two groups ($P > 0.05$) (See **Table 2**).

Discussion

Tracheobronchial foreign body is a common respiratory emergency in children. The foreign body is easily inhaled by infants due to their poor masticatory function and imperfect laryngeal protective reflex and cough reflex, so that the incidence of airway foreign body is significantly higher than that in adults [6-8]. In the present study, 4, 21 and 10 children suffered from intratracheal foreign body, left main bronchial foreign body and right main bronchial foreign body, respectively, which agreed with the theory that the left bronchial foreign body was more common in literatures [9]. Anesthesia management for removal of tracheobronchial foreign body in children should not only ensure adequate ventilation and oxygenation, but also provide a broad perspective and adequate operating time for the surgeons. Our experience and perfect preoperative preparations including preoperative routine chest X-ray or chest CT (if possible) can improve the safety of the surgery to confirm the size and location of the foreign body. All the children were required to be food and drinking fasting for 4 hours. Expectoration and infection control should be conducted to the greatest extent, including encouraging expectoration and using sensitive antibiotics. Full preoperative communication and good cooperation between anesthetists and surgeons is the key to smooth operation [10]. Anesthetists and surgeons should develop jointly the anesthesia and surgical programs, and the first-aid appliances should be prepared in advance. In endoscopic surgery of the respiratory tract, respiratory secretions may induce bad respiratory reflex so that the surgical field was blurring. Frequent respiratory suction may cause a rapid decrease of oxygen concentration in lungs, thus possibly resulting in pulmonary atelectasis. Therefore, adequate anticholinergic medicines should be adopted before operation [11].

Rigid bronchoscope is difficult to operate, is prone to cause damage to the throat and cannot reach bronchus segmenta and thinner bronchus [12, 13]. According to the opinion of some authors, rigid bronchoscope has a good vision and clamping force so that it can treat faster and more effectively the life-threatening airway tumors and larger airway foreign bodies compared to bronchofiberscope [14, 15]. In the study, one child who suffered from larger intratracheal foreign body experienced success in removal of the foreign body under a rigid bronchoscope after repeated failure under a bronchofiberscope. Good sedation can improve the success rate of removal of airway foreign body [16]. Propofol has the advantages of fast response, short half-life, obvious bronchiectasis and suitable pharmacokinetic characteristics for anesthesia of bronchoscopy-assisted surgery. Succinylcholine is an ultra-short acting depolarizing muscle relaxant and has the following advantages of rapid response and recovery; meanwhile, it can degrade by cholinester-

ase in the body, is independent of hepatic and renal function, can effectively prevent various intraoperative adverse reactions in the airway and would not increase the airway secretions in patients with respiratory tract inflammation with fewer perioperative complications. In the study, compared to ASA II patients, the incidences of intraoperative hypoxemia and hypertension or hypotension in ASA III or IV patients were higher, and the bronchofiberscopy time and awakening time was longer in such patients, which may be related to severe disease, larger foreign body, longer time of removal and others.

There have been reports of the application of various ventilation methods in bronchofiberscope-assisted removal of airway foreign body. Compared to controlled breathing, due to a high risk of induction of insufficient pulmonary ventilation (in deep anesthesia) or intraoperative sudden coughing, body movement and bronchospasm (in light anesthesia), spontaneous breathing may increase the difficulty of the operations and even can be life-threatening [17, 18]. According to a 18-year retrospective study including 1035 children by Hasdiraz et al, the adverse reaction incidence of the airway was higher in < four-year-old children undergoing bronchofiberscope operations with reserving spontaneous breathing [19]. In the study, muscle relaxant was used for breathing control to avoid coughing in the process of the bronchofiberscope operation, thereby affecting removal of the foreign body and causing displacement of laryngeal mask. After the adapter tip diameter of Broncho-Cath™ Right doublelumen endobronchial tube (Mallinckrodt Medical Corporation, Ireland) was expanded appropriately with sharp blade in accordance with the diameter of selected bronchofiberscope, the bronchofiberscope was inserted from the operating pole in the tip to facilitate the surgeons' operations and airway suction. Connection of the adapter to the anesthesia equipment and manual control of breathing ensure the ventilation space of the narrow airway and keep the continuity of the operations. Direct insertion of the bronchofiberscope from the laryngeal mask airway into the trachea reduces the throat and airway damage caused by repeated operations and the laryngeal mask airway can prevent microaspiration and intraoral secretions entering into the airway. The intraoperative oxygen supply in children significantly improved compared to the preparation in the study. In the process of the bronchofiberscope operations, head-down position should be adopted, which is conducive to postural drainage and removal of foreign body [20]. After the end of the surgery, the ventilation with the laryngeal mask airway was performed until the patients recovered well, thus reducing dysphoria during awakening and postoperative hypoxemia.

From the above, in removal of tracheobronchial foreign body in infants and children, the application of appropriately modified adapter Broncho-Cath™ Right double-lumen endobronchial tube and laryngeal mask airway for breathing control after intravenous anesthesia can improve the ventilation function, maintain the operational continuity and improve the safety in the preoperative period. Therefore, this method is worthy of being applied widely in clinic.

Disclosure of conflict of interest

None

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