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Efficacy of manual jet ventilation using Manujet III for bronchoscopic airway foreign body removal in children

Li Shaoqing[1], Liu Yuqi[1], Tan Fang, Chen Junliang, Chen Lianhua[*]

Department of Anesthesiology, Eye, Ear, Nose and Throat Hospital, Fudan University, Shanghai 200031, China

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ABSTRACT

Objectives: To evaluate the efficacy of a manual jet ventilation device for bronchoscopic removal of foreign bodies in children.
Methods: 360 children aged from 10 months to 12 years old undergoing rigid bronchoscopy for airway foreign body (FB) removal from February 2005 to June 2009 were included in the study. Patients were randomly divided into three groups of 120 patients per group (S, P and J). In group S, anesthesia was induced with propofol and γ-hydroxybutyrate sodium and maintained by intermittent bolus administration of propofol; the patients were breathing spontaneously throughout the procedure. In group P, anesthesia was induced with propofol (4–5 mg/kg), fentanyl (1–2 μg/kg) and succinylcholine (2 mg/kg). Mechanical ventilation was performed through the side arm of the rigid bronchoscope. In group J, the patient received propofol, fentanyl and succinylcholine as the same doses administered in group P, and manual jet ventilation was performed by using the Manujet III device. Condition for insertion of bronchoscope, occurrence of hypoxemia, successful rate of FB removal, the duration of the operation, the time of emergence and recovery from anesthesia, and perioperative complications (adverse events) were recorded.
Results: Groups P and J had significantly higher rates of successful bronchoscope insertion ($P < 0.05$), significantly higher success rates for FB removal ($P < 0.05$), and lower incidences of hypoxemia during intra- and post-operative periods when compared with group S. Perioperative complications were lower ($P < 0.05$), duration of operation was shorter, and emergence from anesthesia was faster ($P < 0.05$) in groups P and J when compared with group S. Incidences of hypoxemia were lower in Group J when compared with Group P ($P < 0.05$).
Conclusion: This study confirmed the safety and efficacy of performing manual jet ventilation with Manujet III in foreign body removal by rigid bronchoscopy in children.

1. Introduction

Aspiration of a foreign body (FB) into the airway is often a life-threatening event in children. A particular challenge to anesthetists is that the airway must be shared with the surgeon during FB removal. It is difficult to maintain adequate ventilation, oxygenation and anesthetic depth without disturbing the operation. Also, the methods of anesthetic management and modes of ventilation during bronchoscopic FB removal vary greatly among institutions and anesthetists.

Since the introduction of the rigid bronchoscope, the rate of successful removal of FB has increased dramatically and the safety of the operation has improved [1,2]. However, hypoxemia is still a common occurrence during the procedure. Jet ventilation has been widely used as an emergent measure for maintaining an open airway; it has the advantage of providing adequate ventilation and oxygenation without interfering with the operating field [3,4]. The Manujet III (VBM Medizintechnik GmbH, Germany) is a portable and easily regulated device that can be used for manual jet ventilation with a low volume of mechanical dead space. This study was designed to evaluate the efficacy of manual jet ventilation using Manujet III for airway FB removal in children in comparison to other ventilation techniques.

2. Patients and methods

2.1. Patient information

Approval was obtained from the hospital's Human Research Committee prior to the study. The study was carried out from February of 2005 to June of 2009. A total of 360 children, ASA I or II,

* Corresponding author. Tel.: +86 13816880840; fax: +86 21 64377151.
E-mail address: chenlianhua@citiz.net (L. Chen).
[1] These authors equally contributed to this work.

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aged from 10 months to 12 years, weighing 8–35 kg, who required removal of an airway FB were enrolled in the study. All surgical manipulations were performed with Karl-Storz rigid bronchoscopes under general anesthesia. Informed consent was obtained from parents or legal guardians before the initiation of anesthetic and surgical procedure. Exclusion criteria included: (1) inability to obtain parental consent, (2) no foreign body found by bronchoscopy, and (3) absence of spontaneous breathing, cyanosis, or SpO_2 <90% was detected prior to the operation. The presence of a supraglottic/glottic foreign body suggested by clinical symptoms and chest radiography findings or confirmed by laryngoscopy was also excluded from the study. The data were collected in the operating room and ward. Each outcome was observed under the same set of conditions and recorded at same time to avoid bias. Participants were blinded, observers were partially blinded, while surgeons and anesthetists were not blinded in the study.

2.2. Management of anesthesia and ventilation

Atropine (0.01 mg/kg) and methylprednisolone (2 mg/kg) was given intravenously to all patients before anesthetic induction. Patients were randomly divided into three groups ($n = 120$). In group S, anesthesia was induced with propofol (2 mg/kg) and γ-hydroxybutyrate sodium (70 mg/kg) and maintained by bolus administration of 1–2 mg/kg propofol as needed. The patient was allowed to breathe spontaneously at this level of anesthesia. Following successful insertion of a rigid bronchoscope, pure oxygen was delivered at a flow rate of 8 L/min by connecting the respiratory circuit to the side arm of the bronchoscope.

In Group P, anesthesia was induced with propofol (4–5 mg/kg), fentanyl (1–2 μg/kg) and succinylcholine (2 mg/kg) and maintained by bolus administration of 1–2 mg/kg propofol and 2 mg/kg succinylcholine as needed. The respiratory circuit was connected to the side arm of the bronchoscope and manual intermittent positive pressure ventilation (IPPV) was performed at the rate of 16–35 ventilations/min. A larger than normal tidal volume was delivered to offset the leakage of oxygen through the open eye piece of bronchoscope. The chest wall movement of the patients was closely observed to assure adequate ventilation.

In group J, patients received the same anesthetic protocol as in Group P. A small catheter was inserted transnasally into the trachea under the guidance of a laryngoscope and connected to the Manujet III device (VBM Medizintechnik GmbH, Germany. See Fig. 1). Jet ventilation was manually controlled throughout the operation with the driving pressure of 0.6–1 bar in children aged less than 12 months or 1–2.5 bar in children aged more than 1 year (1 bar = 10^5 Pa) at a frequency of 20–35 ventilations/min. The effectiveness of ventilation was assessed by degree of chest excursion. After the FB removal, spontaneous respiration or assisted ventilation was maintained through a facemask in Groups S and P. In Group J, the jet catheter was kept in the trachea and jet ventilation was continued until spontaneous respiration resumed.

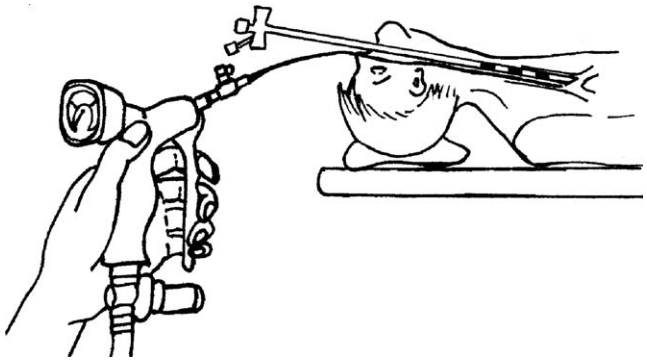

Fig. 1. Manual jet ventilation during FB removal: a small catheter was inserted transnasally into the trachea and connected to Manujet III device during rigid bronchoscopy.

Prior to the start of the insertion of bronchoscope, 1% lidocaine aerosol was sprayed over the epiglottis using laryngoscopic guidance in all groups of patients.

2.3. Measurements

The condition for insertion of bronchoscope was regarded as satisfactory when the bronchoscope was inserted successfully on the first attempt with a clear view of the glottis and without patient's body movement or bucking. Hypoxemia was defined as a decrease in pulse oxygen saturation (SpO_2) < 90% for >5 s.

Beside the baseline medical conditions and condition that required the procedure, the following information was recorded for each patient: successful insertion of bronchoscope on the first attempt, occurrence of hypoxemia during bronchoscopy and after withdrawing the bronchoscope, successful rate of FB removal, the duration of the operation, the time of emergence and recovery from anesthesia, and perioperative side effects including laryngospasm, arrhythmias, breath holding, and post-op restlessness. Patients were discharged from this study if no foreign body was found during the operation. If the presence of a foreign body was confirmed but could not be removed in the first attempt of bronchoscopy, a second attempt was made 3–5 days later, and a thoracotomy should be taken after two times of unsuccessful bronchoscopy. The ventilation mode and anesthetic technique for the second bronchoscopy were chosen based on the anesthetist's preference, and, in some cases, on the surgeon's preference. In those cases, only the first attempt was included in the study and was classified as unsuccessful foreign body removal. Whether the second attempt was successful or not, the patient was not included in the study. No thoracotomy was performed in the study.

2.4. Statistical analysis

All data were analyzed by SPSS 11.5 software. Data with normal distributions are expressed as means ± standard deviation and one-factor analysis of variance was used for comparisons between groups. Data with non-normal distributions are expressed as median (range [interquartile range]), and the rank test was used for comparison between groups. χ^2 tests were used for comparison of categorical data between groups. A P-value <0.05 was considered statistically significant.

3. Results

The data structure of each group was identical, and demographic and epidemiologic data were comparable among the three groups (Table 1). Table 2 presents the clinical and surgical data for the three groups. Compared with group S, groups P and J showed significantly higher success rates of bronchoscope insertion on the first attempt, lower rates of intra- and post-operative hypoxemia, lower rates of perioperative complications, shorter durations of operation, and faster recoveries and emergence from anesthesia ($P < 0.05$). The incidences of hypoxemia were lower in Group J compared with that in Group P ($P < 0.05$). There were no significant differences among groups for the other data that were collected.

4. Discussion

In the current study, three types of ventilation methods were compared in patients undergoing rigid bronchoscopy for airway FB removal. We found that the patients with spontaneous breathing