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ORIGINAL ARTICLE

Combined use of adult fiberoptic bronchoscope and CARTO catheter for tracheal intubation in children with known difficult airway

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Abstract
Purpose To find an alternative device to solve the difficult airway in children.
Method Fifteen patients, all ASA I–II, aged from 1.5 to 9 years, who were undergoing elective surgeries were included. Difficult endotracheal intubation, but not difficult ventilation, was possible for all. The adult fiberoptic bronchoscope (FOB) was used to provide a vision of the glottis, and the CARTO catheter (a cardiac interventional catheter) with adjustable tip was used to induce the endotracheal tube.
Results All patients were successfully intubated within 1–2 min at the first attempt.
Conclusion Combined use of adult FOB and CARTO catheter may be an alternative device for tracheal intubation in children with known difficult airway.

Keywords Difficult airway · Fiberoptic intubation · Child

Introduction

The difficult airway in children presents a challenge to anesthesiologists, and various techniques have been used. Fiberoptic intubation plays a central role in difficult airway management in children [1, 2]. In most medical centers in China, however, the pediatric fiberoptic bronchoscope (FOB) may not be available. There is an urgent need to find an alternative device to solve this problem. Use of an adult FOB to facilitate endotracheal intubation in children with difficult airway recently has been reported by some authors. Arora et al. [3] introduced a method in which the endotracheal tube (ETT), parallel with the adult FOB, was directly advanced into the glottis under direct vision. Hasan and Black [4] and Xue et al. [5] described a two-stage intubation technique. First, the small-diameter steerable guidewire was passed into the trachea through the suction channel of an adult FOB under direct vision. Then, the ETT was smoothly advanced over the steerable guidewire into the trachea after withdrawing the FOB. These techniques are time consuming, however, and suitable only for children who are breathing spontaneously. Thus, we need a device with adjustable direction similar to the FOB that guides the ETT into adult fiberoptic vision and trachea quickly. The CARTO catheter (Biosense Webster, Diamond Bar, CA, USA), which is primarily used in cardiac interventional treatment [6], has a tip with adjustable direction and moderate hardness. We combined an adult FOB with the CARTO catheter to facilitate endotracheal intubation in children with known difficult airways.

Materials and methods

Following Research Ethical Committee approval and written informed consent from parents, three anesthesiologists, each having experience with operation of the FOB, consented to participate in this study. Fifteen ASA I–II patients 1.5–9 years old who were undergoing elective surgeries were included. Preoperative airway assessments for the patients revealed the possibility of difficult endotracheal intubation but not difficult ventilation. Essential devices must always be prepared to secure a surgical

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Fig. 1 An appropriate-size endotracheal tube (ETT) was selected and loaded to the well-lubricated CARTO catheter

Fig. 2 The main operator inserted a CARTO catheter from the nostril. An experienced assistant passed an adult fiberoptic bronchoscope (FOB) into the oropharynx via the oral route

airway. Emergency tracheotomy or cricothyroidotomy would be done if necessary.

The children were routinely fasted preoperatively and received premedication with ketamine 5 mg/kg intramuscularly outside the operating room. On arrival in the operating room, the children were monitored with ECG, noninvasive blood pressure, and pulse oximeter saturation (SpO_2). A 22G intravenous cannula was inserted, and atropine 0.02 mg/kg was given intravenously before anesthesia induction. A selected appropriate-size ETT was loaded to the well-lubricated CARTO catheter and positioned close to the control hand (Fig. 1). After preoxygenation, anesthesia was induced with sevoflurane through the "step-by-step technique." If the child was easily ventilated with a mask, succinylcholine 2 mg/kg was given intravenously. After induction of anesthesia, jaw thrust was performed by an experienced assistant (who has been trained in the technique by the senior author) who stood facing the patient from the patient's left side. Another experienced assistant then passed an adult FOB (OLYMPUS BF-P60; outer diameter, 5.0 mm) into the oropharynx via the oral route. Once the glottis was visualized, the assistant was asked to stabilize the distal end of the FOB. The main operator inserted a CARTO catheter from the mouth or nostril, then advanced the CARTO catheter slowly from the right corner of the oral cavity until its tip was located between the FOB and the glottis; then the tip passed through the glottis under direct vision successfully (Figs. 2, 3). If under direct vision the CARTO catheter tip did not lie around the glottis, it could be adjusted by moving the tip forward or backward through the control handle. Once the CARTO catheter was successfully inserted into the trachea, the ETT was then smoothly advanced over the CARTO catheter into the trachea (Fig. 4), and the FOB and CARTO catheter were removed.

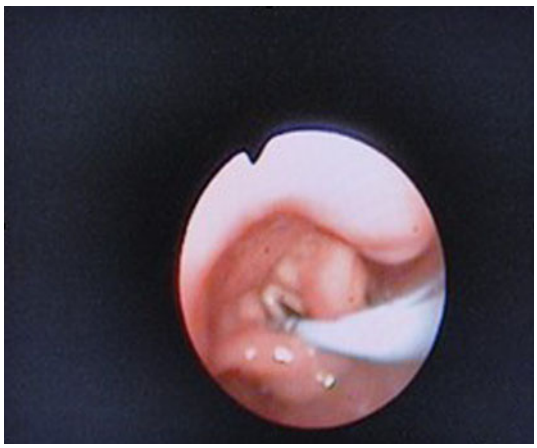

Fig. 3 The CARTO catheter tip lies in the glottic opening under vision from the FOB

Fig. 4 The endotracheal tube (ETT) is advanced over the CARTO catheter into the trachea

Table 1 Patient data

No.	Diagnosis	Planned surgery	Sex	Age (years/months)	Weight (kg)	Mouth opening (cm)
1	TMA	AP	F	5 (6/12)	18.5	2.5
2	MFSD	SR	M	1 (5/12)	10	1.5
3	MFSD	SR	M	3 (7/12)	18.6	2.0
4	MFSD	SR	M	2 (1/12)	12.6	1.8
5	MF	ORIF	F	5	22	2.5
6	CTBSCD	SR	F	8 (2/12)	30	Normal/LHT
7	TMA	AP	M	6	15.4	2.3
8	TMA	AP	M	7 (5/12)	19.6	2.2
9	MF	ORIF	M	5 (4/12)	21.5	1.7
10	TMA	AP	M	7	16.5	2.8
11	CTBSCD	SR	F	1 (10/12)	11.6	Normal/LHT
12	MFSD	SR	M	4 (9/12)	19	2.6
13	TMA	AP	F	6 (3/12)	16	2.9
14	MFSD	ORIF	F	3	17.2	2.1
15	CTBSCD	SR	M	5 (5/12)	19.5	Normal/LHT

TMA temporomandibular ankylosis, *AP* arthroplasty, *MFSD* maxillofacial burn scars deformity, *SR* scar repair, *MF* mandibular fracture, *ORIF* open reduction with internal fixation, *CTBSCD* cervicothoracic burn scar contracture deformity, *normal/LHT* child with normal mouth opening but with limited head tilt

Correct position of the tracheal tube was confirmed by auscultation and capnography. The tracheal tube was then connected to the circle breathing system of an anesthesia machine for ventilation.

Results

Fifteen patients with oral and maxillofacial deformity, aged 1.5–9 years old, who were undergoing elective surgery were included. Among 15 cases in this series, there were 11 cases of limited mouth opening and 4 cases of limited head tilt (see Table 1). All the patients were successfully intubated within 1–2 min at the first attempt. Oxygen saturation reduced to below 90% in 2 cases, whereas heart rate increased by 20% in 6 cases, probably attributable to the cardiovascular reaction to intubation.

Discussion

The CARTO catheter is a common cardiac interventional catheter that was originally applied in radiofrequency catheter ablation for severe arrhythmia such as atrial fibrillation. The direction of the head part can be adjusted through the distal end of the CARTO catheter, and it has an appropriate hardness. Based on these characteristics, we initially brought it into adult FOB-assisted pediatric intubation with a known difficult airway. The CARTO catheter plays the role of a flexible, direction-adjusted stylet with a good support for ETT. It has an outer diameter of roughly 2.0 mm, so a 3.0-mm ETT can be railroaded over it. It is particularly suitable for small children.

This technique needs good cooperation between the operator and assistant. Skilled FOB-guided intubation technique is very important for operators. In children, oxygen consumption is too high for them to tolerate long-time intubation, so the technique is not suitable for children with suspected difficult ventilation. Detailed preoperative evaluation of airway and backup protocol of airway management are essential. We strongly recommend that the technique is employed by novices in children with spontaneous breathing. Simultaneously, if conditions permit, pediatric FOB is still the gold standard for difficult airway management in children.

In short, we believe that this technique combining an adult FOB and the CARTO catheter for tracheal intubation is perhaps a reliable alternative method for children with known difficult airway when a pediatric FOB is not available.

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