CASE REPORT



High-frequency jet ventilation combined with endobronchial blocker for extraction of tracheal foreign body: a case report



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Abstract

Background A foreign body (FB) in the airway is a potentially life-threatening clinical condition requiring prompt medical intervention. Due to the diverse nature of airway foreign bodies, distinct strategies should be tailored based on their types. Improper management may not only prevent successful removal but also endanger the patient's life. In this case, we successfully removed a tracheal FB using high-frequency jet ventilation (HFJV) combined with an endobronchial blocker, thus providing clinicians with a novel approach for airway FB extraction.

Case presentation We present the case of an 8-year-old girl admitted to the emergency room following accidental foreign body aspiration, accompanied by coughing and chest pain. Flexible bronchoscopy revealed a round foreign body above the carina. Attempts at oral removal failed due to the foreign body's smooth surface. However, the foreign body was successfully removed with HFJV, which preserved the child's spontaneous respiration. The procedure was performed under general anesthesia using remimazolam and remifentanil, along with an endobronchial blocker and rigid bronchoscopy. The patient had an uneventful recovery and was discharged on postoperative day 15, remaining asymptomatic with no sequelae at the 6-month follow-up.

Conclusion Our case showed a novel approach to tracheal FB removal, which may improve success rates and reduce complications in select cases.

Keywords High frequency jet ventilation, Endobronchial blocker tracheal, Foreign body, Remimazolam

Background

In medicine, a "foreign body" (FB) refers to an object lodged in the larynx, trachea, and bronchi. This is particularly common in infants and young children under 3 years of age [1-2]. Airway foreign bodies (AFBs) in children represent a significant public health concern, as their presence is life-threatening and necessitates surgical

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removal [2]. Although various anesthesia strategies and ventilation methods exist for FB extraction, rigid bronchoscopy under general anesthesia is commonly used to minimize complications [3]. However, there is no consensus on the optimal ventilation modality for general anesthesia in such case. Anesthesia management for confirmed major airway foreign bodies presents significant challenges: precipitously deepening anesthesia may suppress spontaneous respiration, leading to complete airway obstruction and rescue failure, while insufficient anesthetic depth cannot meet surgical requirements.

In this case report, the combination of Remifentanil and Remimazolam infusions achieved both adequate



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Fig. 1 Intratracheal foreign body (FB) in an 8-year-old girl. A. Axial computed tomography (CT) image of the neck demonstrated a FB at the tracheal midline (arrow). B Three-dimensional (3D) CT reconstruction shows a high-density FB shadow within the tracheal lumen, localized slightly superior to the carina (bifurcation of the main bronchi)



Fig. 2 Intratracheal foreign body in an 8-year-old girl. A. Preoperative fibre-optic bronchoscopy revealed a red, bead-like foreign body ($1.3 \text{ cm} \times 1.5 \text{ cm}$) located above the carina, with a central hole completely obstructing the right main bronchial orifice

anesthetic depth and maintained spontaneous respiration. To optimize oxygenation and compensate for intraoperative tidal volume insufficiency caused by reduced thoracic mobility, HFJV was utilized. This approach satisfied oxygenation requirement while providing surgeons with optimal conditions. Furthermore, using an endobronchial blocker for foreign body retrieval offers clinicians an innovative method for tracheal FB removal.

Case presentation

An 8-year-old child was referred to our hospital 14 h after accidental FB aspiration. The clinical symptoms included intermittent coughing, chest pain, wheezing, nausea, and vomiting. The child was generally healthy but had a significant medical history. She was transferred to

the emergency department, where she was conscious and coherent. Her vital signs were stable, with a blood pressure of 100/52mmHg, respiratory rate of 25 breaths/min, and pulse rate of 100 beats/min. A physical examination revealed coarse breath sounds, wheezing, and phlegm sounds on auscultation of both lungs. Chest computed tomography with three-dimensional reconstruction showed a high-density shadow slightly above the carina, suggestive of an FB (Fig. 1). Bronchoscopy revealed a red bead (approximately 1.3 cm \times 1.5 cm) above the carina, with a central hole completely obstructing the right main bronchus. Sputum adhered to the surrounding area, causing poor ventilation (Fig. 2).

Her routine coagulation values were slightly elevated. Electrocardiography showed sinus tachycardia and arrhythmia. She was preoperatively diagnosed with a trachea FB, and bronchoscope removal was planned. To avoid thoracic surgical trauma, we opted for non-endotracheal intubation to maintain spontaneous breathing, combined high-frequency jet ventilation (HFJV) for tracheal FB extraction.

The patient entered the operating room breathing spontaneously. Routine monitoring showed a peripheral capillary oxygen saturation (SpO₂) of 91%, heart rate of 118 beats/min, and blood pressure of 102/61 mmHg. Anesthesia was induced with intravenous sufentanil (5 μ g), penehyclidine (0.3 mg), and remimazolam (10 mg). The child maintained spontaneous respiration. After loss of consciousness, a No. 2 double-lumen laryngeal mask was inserted to facilitate ventilation. Anesthesia was maintained with an intravenous infusion of remimazolam (1 mg/kg/h), remifentanil (0.2 μ g/kg/min), and 2% sevoflurane in oxygen.



Fig. 3 Intratracheal foreign body (FB) in an 8-year-old girl. A Simple diagram of intratracheal FB removal assisted by an endobronchial blocker. B The removed FB

The patient was placed in the supine position, but attempts to remove the FB using a fiberoptic bronchoscope were unsuccessful. The fiberoptic bronchoscope was withdrawn, sevoflurane was discontinued, and the laryngeal mask was removed. The patient was placed in a 30° head-down tilt position to minimize secretion and prevent the FB from migrating distally. Simultaneously, an assistant stabilized her head, the vocal folds were exposed using a direct laryngoscope, and the highfrequency ventilator's delivery tube was connected to the bronchoscope's side port for closed-circuit oxygenation. The rigid bronchoscope was then advanced into the airway under high-frequency ventilator support. The bronchoscope settings were as follows: FiO2 100%; respiratory rate, 16 breaths/min; I:E ratio 1:1.5; driving pressure 1.1; and peak inspiratory pressure 30 cmH2O. The patient maintained spontaneous breathing throughout the procedure, with oxygen saturation consistently above 96%.

During surgery, a smooth, oval, bead-like FB with small holes was observed at the carina. The surgeon repeatedly attempted to clamp the bead with an FB clamp, but its smooth surface caused it to slip repeatedly during manipulation toward the vocal folds, resulting in multiple failed attempts to secure it. The anesthesiologist proposed slowly inflating a No. 5 endobronchial blocker, Once the bronchial blocker was carefully advanced past the FB, the cuff was inflated and secured beneath it. The surgeon used the FB clamp to grasp the bead while the anesthesiologist gently pulled the blocker (Fig. 3A). The blocker cuff not only prevented the FB from slipping distally and obstructing the trachea but also provided support for the FB clamp to grasp and maneuver the bead toward the vocal folds.

Due to the child's narrow vocal folds, the FB could not be extracted despite multiple attempts with the bronchoscope. Consequently, the bronchoscope was withdrawn and a tracheotomy was performed to extract the FB. The anesthesiologist administered 8 mg of mivacurium intravenously, and the surgeon inserted a No. 5 tracheal tube into the subglottis under visual laryngoscopy, followed by a tracheotomy to remove the FB (Fig. 3B). The surgeon then inserted and secured a size 6.5 endotracheal tube with a balloon, which was subsequently removed. The child's vital signs remained stable, and she was transferred to the pediatric intensive care unit on ventilator support. The surgery lasted 3 h, with the lowest recorded SpO_2 being 96%. Due to the child's prolonged head-down position, 5 mg of dexamethasone was administered intravenously to reduce brain and organ oedema. The child was weaned from mechanical ventilation 1 day postoperatively, the tracheal incision was closed after 10 days, and she was discharged 15 days after surgery. The tracheostomy was closed 3 months later, and the child remained healthy with no sequelae at the 6 months follow-up.

Discussion

Pediatric airway foreign bodies (AFBs) are common clinical emergencies, frequently associated with pulmonary infection and varying degrees of hypoxia; severe cases may lead to asphyxia and respiratory distress. Rigid bronchoscopy is the first-line diagnostic and therapeutic approach for FB-induced airway obstruction [4]. in this case, however, we successfully removed an intratracheal FB using an endobronchial blocker. To our knowledge, this is the first reported case of its kind.

Airway management is critical during tracheal FB removal, as the anesthesiologist and surgeon share the airway. Continuous surgery under general anesthesia with a rigid ventilating bronchoscope is currently the

safest approach for FB removal. However, serious complications, including hypoxemia and even death, can occur during rigid tracheobronchoscopy [5]. Appropriate anesthesia is critical for reducing mortality and severe complications rates. In this case, we used non-tracheal intubation with preserved spontaneous breathing under general anesthesia, combined with HFJV. General anesthesia reduces restlessness in children, relaxes tracheal smooth muscles, and facilitates FB removal [3]. HFJV is a safe and effective ventilation.

technique characterized by high frequency, low mean airway pressure, and small tidal volumes. Unlike traditional mechanical ventilation, HFJV relies on turbulent gas flow and oxygen dispersion for gas exchange, improving oxygenation and alleviating hypoxia. The small tidal volume minimizes mechanical damage from shear forces [6].

A key advantage of HFJV is its use of open-jet ventilation, which ensures excellent visibility, surgical continuity, and preservation of spontaneous breathing. High-frequency ventilation meets the patient's oxygen requirements while the pressure it generates displaces secretion near the FB, enhancing visibility and surgical success. However, despite ensuring oxygenation through non-tracheal intubation and spontaneous breathing with HFJV, carbon dioxide (CO2) retention remains a significant concern. Unfortunately, continuous and accurate end-tidal CO2 monitoring was not feasible in pediatric patient during HFJV with preserved spontaneous breathing. Blood CO2 levels could only be accessed intermittently via arterial blood gas (ABG) analysis. Excessive CO2 accumulation may.

led to hypercapnia-induced circulatory instability, while rapid CO2 elimination in later stages risks precipitating CO2 washout syndrome.

Therefore, ensuring adequate oxygenation is critical when managing potential hypercapnia in non-intubated spontaneous under anesthesia. HFJV effectively addresses this challenge. Moreover, preserved spontaneous breathing allows patients to autonomously adjust their respiratory rate, thereby mitigating the risk of CO2related complication.

In this case, remimazolam demonstrated unique advantages in preserving spontaneous respiration during non-tracheal intubation.

As a novel benzodiazepine intravenous anesthetic, remimazolam offers rapid onset, a short half-life, mild respiratory and circulatory inhibition, and predictable recovery [7]. These properties facilitated the child's stable condition throughout the procedure. Oxygen saturation remained \geq 96% throughout, with no adverse events such as body reactions, respiratory depression, or choking. Additionally, the depth of anesthesia was well-maintained. Since the optimal pediatric maintenance dose of

remimazolam is undetermined, we used the highest adult dose (1 mg/kg/h). The child remained hemodynamically stable throughout the procedure and experienced no postoperative complications, indicating that remimazolam is a viable option for tracheal FB removal in children.

The use of an endobronchial blocker to assist in FB removal is a key highlight of this case. Given the FB's unique characteristics, the endobronchial blocker prevented dislodgement and provided critical support during extraction. This case demonstrates a novel approach to tracheal FB removal, which may improve success rates and reduce complications in select cases.

Conclusion

For the treatment of special types of tracheobronchial foreign bodies, clinicians should develop scenario-specific surgical plans and select tools adapted to clinical contexts to improve success rates and reduce complications. In this case, a foreign body was successfully removed from a pediatric trachea using high frequency jet ventilation combined with a bronchial blocker, while preserving spontaneous breathing. This approach provides an innovative strategy for tracheobronchial foreign body removal.

Abbreviations

FBForeign bodyAFBsAirway foreign bodiesHFJVHigh-frequency jet ventilation

Supplementary Information

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Supplementary Material 1

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Author contributions

Y. L. analyzed and interpreted the patient data, handled the manuscript. W.L. helped conceive and design the study. Y.W. and Q.Z. revised the manuscript. All authors read and approved the final manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Consent for publication

We confirming that written informed consent has been provided by the parents to have the case details and accompanying images published.

Competing interests

The authors declare no competing interests.

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