

Clinical Analysis of Bronchoscope Diagnosis and Treatment for Airway Foreign Body Removal in Pediatric Patients

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Abstract

Background: With the wide application and technical development of flexible and rigid bronchoscopy, the method of removing airway foreign body has developed from the single use of foreign body forceps to different techniques for different foreign bodies.

Methods: Selected 633 children who were diagnosed as airway foreign bodies by the Department of Respiratory Intervention, Children's Hospital affiliated to Shandong University from January 1, 2018 to December 31, 2021, and the airway foreign bodies were diagnosed via bronchoscopy. After comprehensive evaluation about the nature of the foreign body in the airway, removed the foreign body with the foreign body forceps, freezing, laser, electrocoagulation, balloon and other techniques, observed the success rate of the foreign body removed from the airway, the percentage of the foreign body removed using different techniques, the operation time, and the incidence of post-adverse reactions during operation.

Results: The success rate of using flexible bronchoscope alone to remove foreign bodies in the airway was 99.2%. After flexible bronchoscopy, 19 cases of foreign bodies were removed by vacuum suction alone, 513 cases were removed by foreign body forceps alone, 62 cases were combined with cryotherapy, 2 cases were electrocoagulation, 6 cases were mesh baskets, 3 cases were balloons, 5 cases were laser, and various 18 cases of foreign bodies were taken out by technical combination. 5 cases of flexible bronchoscope combined with rigid bronchoscope combined to remove foreign bodies. The operating time ranges from 5min-1h, with an average of 20minutes. There were 17 cases of hypoxemia (2.7%) during the operation, 36 cases (5.7%) of bleeding caused by airway mucosa injury after the treatment, and 70 cases (11.2%) of laryngeal edema. The total incidence of adverse reactions was 19.6%, there were no deaths due to foreign bodies and treatment.

Conclusions According to the different properties of airway foreign bodies, it is safe and effective to select appropriate techniques to extract foreign bodies through the flexible bronchoscope, which can increase the removal rate of airway foreign bodies and reduce the occurrence of serious complications.

Background

Airway foreign body (FB) refer to FB in the larynx, trachea and bronchi, which is more common in infants and children younger than 3 years old, upper respiratory tract obstruction can occur if treatment is not timely, and it can endanger the life of the child in severe cases [1]. Early and accurate diagnosis and early removal of airway FBs can significantly reduce airway complications. With the wide application and technological development of flexible bronchoscopes, different effective methods have been adopted for different FB through flexible bronchoscopes. In the past 3 years, we have adopted flexible bronchoscopes, combining with foreign body forceps, mesh basket, cryosurgery, laser and balloon etc., successfully removed FB in the airway of 628 children, and reported as follows.

Materials And Methods

1.1 Subject

From January 1, 2018 to December 31, 2021, 633 cases of children with AIRWAY FB were considered on chest computerized tomography (CT) and clearly diagnosed by bronchoscopy in the Department of Respiratory Intervention, Children's Hospital affiliated to Shandong University, including 448 males and 185 females; age 6 months ~ 14 years old (average age is about one year and eight month).

1.2 Method

1.2.1 Examination and Treatment Equipment:

(1) Electronic bronchoscope: Evislucer ABF-260 series of electronic bronchoscope produced by Opus Company in Japan: BF-P260F (outer diameter is 4.0 mm, working channel is 2.0mm; Bf-xp260f (outer diameter is 2.8mm, the working channel is 1.2mm). (2) Laser treatment equipment. (3) Electrocoagulation equipment: Including the German ERBE VI0200D + APC2 respiratory endoscopic electro surgery workstation system, OlympusCD-6C-1 column electrocoagulation head. (4) Cryotherapy equipment: freezer: produced by Beijing Kulan Company, the outer diameter of the freezing probe is 1.8mm. Refrigerant: carbon dioxide. (5) Balloon: according to the position of the foreign body mound and the different range of the balloon that can be entered, the balloon of BostonScientific Company, Medtronic balloon and 5061 high-pressure gun pump were selected respectively.

1.2.2 Preoperative preparation:

Blood routine, coagulation routine, infectious markers, electrocardiogram, cardiac ultrasound and chest CT scan were performed before examination and treatment (enhanced scan + 3D airway reconstruction for children with relatively long onset time). Food and water were forbidden for more than 6 hours before examination to prevent aspiration caused by intraoperative vomiting.

1.2.3 Procedure

(1) Under general anesthesia, the bronchoscope enter through the nasal cavity, spray diluted lidocaine through the treatment channel after passing through the glottis for total airway surface anesthesia, remove and aspirate airway secretions, enter the healthy side according to the imaging examination conclusions, and then check each lobe, segment, and sub-segment bronchus on the affected side.

(2) After finding a foreign body in the airway, determine the nature, size, shape, and location of the foreign body. After adjusting the appropriate angle of the foreign body forceps, first gently pull the foreign body after clamping the foreign body, which can indicate that the foreign body is not obviously incarcerated in the lumen. Small non-sharp FB can be attached to the head of the bronchus by vacuum suction or used foreign body forceps and bronchoscope can be withdrawn slowly together. If the foreign body is

incarcerated or there is a small amount of granulation tissue wrapped around it and it cannot move, you can first clamp the foreign body with foreign body forceps and try to loosen it in different directions. If there is more granulation tissue surrounding the foreign body, use freezing or electrocoagulation clean up the granulation tissue, and give active local hemostatic treatment if there is bleeding. After fully exposing the foreign body, select the foreign body forceps or mesh basket according to the shape, size and location of the foreign body.

(3) After the foreign body is removed, it is treated with freezing according to the local airway bleeding, granulation hyperplasia and mucosal damage. After the operation, the bronchoscope should be reviewed in a timely manner, and necrotic materials should be cleaned up, and granulation tissue frozen or electrocoagulated if necessary.

1.3 Clinical Observation Index

The FB' removal success rate, the percentage with different techniques, the operation time, and the incidence of adverse reactions were counted among these 633 cases.

Results

2.1 Types of Foreign body

Among the 633 cases children with airway FB, 564 cases were plant FB, including peanuts (shells), melon seeds (shells), walnut kernels, chestnuts (shells), soybeans, pulp (shells, stems), scallions, pine nuts, almonds, etc., 7 cases of plastic products, 5 cases of milk tea beads, 8 cases of pen caps, 1 case of the wick for LED lamp, 25 cases of bone-like FBs, 2 cases of grass spikes, 2 cases of pine needles, 1 case of spicy striped meat, 2 cases of teeth, 2 cases of hair, particles there were 2 cases of unknown objects, 1 case of thread ends, 2 cases of packaging bags, and the remaining 9 cases were all kinds of unknown foreign objects (Fig. 1)(Table 1). The above airway FBs were removed in 628 cases at one time, and the success rate was 99.2% using flexible bronchoscope alone. The remaining 0.8% of AIRWAY FBs were removed with flexible bronchoscopy combined with rigid bronchoscopy.

Table 1
Type of foreign body

FAB	N	%
Plant FBs	564	89.10%
peanut (or shell)	99	15.64%
melon seed (or shell)	68	10.74%
walnut kernel	56	8.85%
chestnut (or shell)	72	11.37%
soybean	45	7.11%
pulp (or shell, or stem)	79	12.48%
scallion	59	9.32%
pine nut	53	8.37%
almond	33	5.21%
plastic product	7	1.11%
milk tea bead	5	0.79%
pen cap	8	1.26%
the wick for LED lamp	1	0.16%
bone-like FB	25	3.95%
grass spike	2	0.32%
pine needle	2	0.32%
spicy striped meat	1	0.16%
teeth	2	0.32%
hair	2	0.32%
particle (unknown object)	2	0.32%
thread ends	1	0.16%
packaging bag	2	0.32%
unknown object	9	1.42%

2.2 Foreign Body Removal Technique And Duration

Negative pressure suction and removal of FB in 19 cases, FB forceps alone in 513 cases, FB forceps combined with freezing in 62 cases, electrocoagulation in 2 cases, mesh baskets in 6 cases, balloons in 3 cases, lasers in 5 cases, and multiple techniques for combined removal of FB in 18 cases (Fig. 2). Five cases were combined with rigid bronchoscope to remove FB (Table 2). They were one walnut kernel, two pen caps, one plastic foreign body, and one stone-like FB. The removal of the above FBs takes about 5min-1h, and the average is 20 minutes.

Table 2
Foreign body removal technique

	N	%
Negative pressure suction	19	3.00%
FB forceps (A)	513	81.04%
A with		
Freezing (B)	62	9.79%
Electrocoagulation (C)	2	0.32%
Mesh basket (D)	6	0.95%
Balloon (E)	3	0.47%
Laser (F)	5	0.79%
Multiple techniques combined	18	2.84%
A + B + E	5	0.79%
A + B + D	7	1.11%
A + B + D + E	6	0.95%
With rigid bronchoscope	5	0.80%

2.3 Complications And Prognosis:

There were totally 123 cases (19.6%) of complications which occurred in the progress of removing FB under flexible bronchoscopy, mainly 17 cases (2.7%) of hypoxemia during bronchoscopy, which were relieved by increasing the oxygen flow and suspending the operation during the operation; 36 cases (5.7%) of bleeding caused by airway mucosal injury were treated with local adrenaline and thrombin, and if necessary, intravenous hemostatic drugs which is pituitrin was given and all were improved. No operation-related massive hemoptysis was seen; 70 cases (11.2%) there was mild laryngeal edema, which improved after treatment with adrenaline and corticosteroids. No postoperative dyspnea was seen. There were no other serious complications such as postoperative pneumothorax and mediastinal emphysema. There were no deaths.

Discussion

Airway FB is the most common respiratory emergency in children. Aspiration of a foreign body into the airway is usually divided into three stages [2]. The first stage is the sudden impact of a FB into the airway, leading to acute cough, stridor, respiratory distress and cyanosis. This stage is the most dangerous. If a foreign body is trapped in the glottis and airway, it may cause suffocation and even death. The patient usually progresses to an asymptomatic stage, followed by airway FBs that are trapped in a fixed position in the tracheobronchial tree, and the airway reflex gradually weakens over time. The third stage involves complications secondary to chronic airway FB, manifested as infections, such as recurrent pneumonia, chronic cough, unilateral wheezing, or asthma-like symptoms. Further delay in the diagnosis of airway FB may lead to bronchiectasis and permanent damage to lung tissue. Therefore, children with recurrent cough, wheezing, hemoptysis, lung inflammation and other unknown causes after repeated anti-inflammatory treatments should be highly vigilant for airway FB, and bronchoscopy should be perfected as soon as possible to confirm the diagnosis and treatment.

Studies have reported that rigid bronchoscopy has been used as the gold standard for diagnosis and treatment of FB in the airway [3]. However, because the rigid bronchoscope cannot bend, the field of view is narrow. For the foreign body in the deeper part or the FB broken during the removal of the rigid bronchoscope, a flexible bronchoscope should be used to remove the foreign body. In recent years, flexible bronchoscopy technology has gradually been widely used in clinical practice. It has the advantages of simple operation, fast operation, small trauma, and can involve the remote airway. It can also improve the safety of ventilation during the inspection of children's airways. Sexuality, and better control of bronchoscopy during treatment with minimal complications. In this group of studies, the complication of children with airway FB during and after flexible bronchoscopy was 19.6%, and there were no deaths due to FB and treatment. This is consistent with many reports in the literature [4–6]. Therefore, flexible bronchoscopy has become a commonly used method for removing FB in the airway of children.

In this study, the airway FB taken out by the flexible bronchoscope were mainly edible plant FB, which may be related to the immature swallowing mechanism of the child [7]. The success rate of the flexible bronchoscope for removing FB varies from study to study. Tang et al. used flexible bronchoscope to remove FB from the airway of 1027 children with a success rate of 91.3% [8]. Rodrigues et al. reported that the success rate of using 33 cases of flexible bronchoscope to remove FB was 82.5% [9]. In this study, 628 cases of FBs were removed through a flexible bronchoscope, and the success rate of removal was 99.2%. Under normal circumstances, the flexible bronchoscope treatment port can smoothly grasp a part of the airway FB through the foreign body forceps, and some FBs due to the abnormal size, texture, and shape, or due to the long time in the airway, the surrounding granulation tissue proliferation is obvious or even the FB is completely wrapped, and it is difficult to remove the foreign body smoothly with foreign body forceps. For the removal of airway FB of different natures, the flexible bronchoscope can be used alone or in combination with foreign body forceps, net baskets, freezing, balloons, lasers and other technologies. For a small number of intractable airway FB, when there is a risk of massive hemoptysis,

airway perforation, etc., surgical intervention is ultimately required [10, 11]. The 628 cases of airway FBs in this group were successfully removed except 5 cases with rigid bronchoscopy and 123 cases had mild side effects, which were all improved after treatment. There were no major hemoptysis, dyspnea, pneumothorax and other conditions caused. The experience is summarized as follows: (1) For FB that have a short retention time and are particularly small, non-sharp FB can be directly adsorbed on the end of the bronchial lens by negative pressure and slowly moved out of the airway with the bronchoscope. (2) FB with irregular shapes, relatively rough surfaces, and movable FB can be fine-tuned to the appropriate gripping position with foreign body forceps. The clamps are slowly moved out of the airway with the bronchoscope. (3) Smooth, spherical or elliptical, fragile and movable FB. The foreign body can be taken out by freezing or mesh basket. (4) The incarcerated foreign body can be taken out by forceps, and the balloon will slowly pass through the gap between the airway and the foreign body, enter the distal end of the foreign body, expand and pull and cause the foreign body to loosen. Use forceps or mesh basket to take out the remaining FB (5) The foreign body that is wrapped and covered by granulation tissue can be removed by laser, freezing or electrocoagulation to clean the surrounding granulation tissue, and then the foreign body clamp or mesh basket is used to take out the foreign body.

Conclusions

For those who have repeated coughing, wheezing, and recurrent respiratory symptoms after anti-inflammatory treatment, a foreign body is highly suspected, and bronchoscopy should be perfected as soon as possible. According to the different properties of airway foreign bodies, it is safe and effective to select appropriate techniques to extract foreign bodies through the flexible bronchoscope. The appropriate bronchoscopy technology treatment can not only improve the removal rate of airway FB, but also it can shorten the operation time and reduce the occurrence of complications.

Abbreviations

FB
foreign body
CT
computerized tomography

Declarations

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Authors' contributions

LLH,ZXZ,XDT,JM,CM and CXL have full access to all the data in the study and take responsibility for the integrity of the data. LLH,ZXZ,CM and CXL conceived and designed the analysis. LLH,ZXZ,XDT,JM and CXL performed the bronchoscopy for suspected foreign body aspiration. LLH and XDT collected the patients' data. LLH, ZXZ and CXL analyzed and interpreted the data. All authors have read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The study obtained approval from the Ethical Committees of the Children' hospital affiliated to Shandong University (approval number: SDFE-IRB/T-2022006; date of approval: 11 March 2022). Informed written consents were obtained from the parents or guardians of the patients.

Consent for publication

Not applicable.

Conflict of interest

The authors declare that they have no conflict of interest.

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Figures

Figure 1

The appearance of foreign bodies lodged in the bronchus after bronchoscopy.

- a. Pine needle foreign body, surrounded by granulation tissue wrapped, and adhesion of serious infection.
- b. Green gelatinous round foreign body with smooth surface.
- c. LED wick foreign body, the surface is sharp.
- d. The beginning of the candy paper foreign body is sharp, and the surrounding granulation is wrapped.
- e. The blood supply of granulation tissue wrapped on the surface of unknown foreign body is rich.

Figure 2

The treatment of bronchial foreign body under bronchoscopy was performed with many techniques.

- a. Trachea foreign body forceps was used to remove airway foreign body.
- b. The granulation tissue surrounding the foreign body is being treated with laser.

- c. Granulation tissue stimulated by bronchial foreign body was treated with cryotherapy after removal of bronchial foreign body.
- d. The granulation tissue surrounding with abundant blood supply of the foreign body was treated with electrocoagulation.
- e. After the balloon dilation technique was applied to the distal end of the airway where the foreign body was, the foreign body was pulled to the proximal end of the airway and removed.
- f. Mesh basket was used to get the foreign body from the airway.