

Original Article

Inhaled foreign bodies in pediatric patients: a review and analysis of 3028 cases

Chuan-Shan Zang¹, Jian Sun², Hai-Tao Huang³, Yan Sun¹, Jie Qiu¹, Yan Jiang¹, Na Li¹

Departments of ¹Otorhinolaryngology Head and Neck Surgery, ²Anesthesiology, ³International Medical, The Affiliated Hospital of Qingdao University, Qingdao 266003, Shandong Province, China

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Abstract: Objective: Tracheobronchial foreign bodies (TFBs) in children are one of the most universal pediatric emergencies. It is very important to know how to reduce the incidence of serious complications and mortality during the management of TFBs. The study aimed to evaluate the clinical characteristics and management of TFBs in 3028 cases. Methods: We retrospectively reviewed the medical records of 3028 patients [1745 males (57.63%) and 1283 females (42.37%)] with TFBs who underwent rigid bronchoscopy between 1985 and 2015 in the Department of Otorhinolaryngology Head and Neck Surgery. Overall, there were 2875 patients (94.95%) aged 0-4 years, and 153 (5.05%) aged 4-14 years. The location and type of foreign bodies (FBs), clinical manifestations, diagnosis, complications, anesthesia methods and outcome were included in this analysis. Results: The most common FBs in the airway were peanuts in 2530 patients which accounted for 83.55%. FBs were located at the trachea in 334 cases (11.03%), at the right bronchial tree in 1703 patients (56.24%), at the left bronchial tree in 974 cases (32.17%), at bilateral bronchial trees in 15 cases (0.50%), and at glottal area in 2 cases (0.07%). Tracheotomy was performed in 4 patients. Four patients (0.31%) died. Conclusions: Rigid bronchoscopy under general anesthesia combined with adequate surface anesthesia of local mucosa is a very safe and effective way in the management of foreign bodies. The procedure of rigid bronchoscopy should be carried out by skilled ENT specialists and anesthetists to reduce the incidence of serious complications.

Keywords: Rigid bronchoscopy, tracheobronchial foreign body, anesthesia, inhaled foreign bodies, children

Introduction

Tracheobronchial foreign bodies (TFBs) are one of the most universal pediatric emergencies, which deserve early diagnosis and successful management. TFBs are a common cause of accidental death at home in children under 4 years of age [1-7]. Most of TFBs can be removed by rigid bronchoscopy. However, it is full of risks during the procedure. The operation must be accomplished by ENT specialists and anesthesiologists because it often results in serious complications such as bronchospasm, pneumomediastinum and heart arrhythmias. Rigid bronchoscopy has been used to remove TFBs for several decades. The purpose of this article was to report our experience on the management of TFBs and results of the rigid bronchoscopy for foreign body aspiration in children.

Materials and methods

All the patients younger than 14 years who were directed to our hospital due to TFBs be-

tween 1985 and 2015 were retrospectively reviewed, and a total of 3028 cases were enrolled in the study. All the children underwent rigid bronchoscopy under general anesthesia combined with adequate surface anesthesia of local mucosa. The following methods were used to treat patients before and after the operation: controlling different complications before surgery; using antibiotics and inhaling oxygen; formulating a different treatment according to the different type and possible location of foreign bodies; and monitoring vital signs of the patients. During removal of foreign bodies, irrigation therapy was carried out in some patients who had obvious inflammation of the bronchus or pulmonary atelectasis. Normal saline or antibiotic solution was used for irrigation therapy. Adrenaline was used to relieve bleeding and edema of the bronchus during endoscopic examination. All cases underwent chest radiography or fluoroscopy before they were discharged from the hospital, which could help to determine if there were

Inhaled foreign bodies pediatric patients of 3028 cases

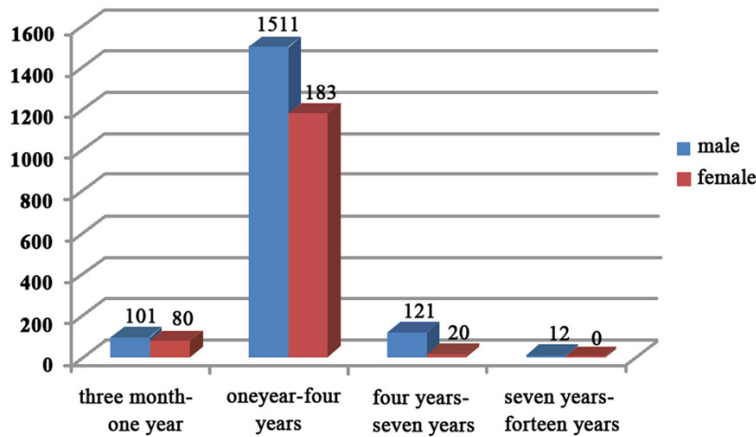


Figure 1. Age and sex distribution of the patients.

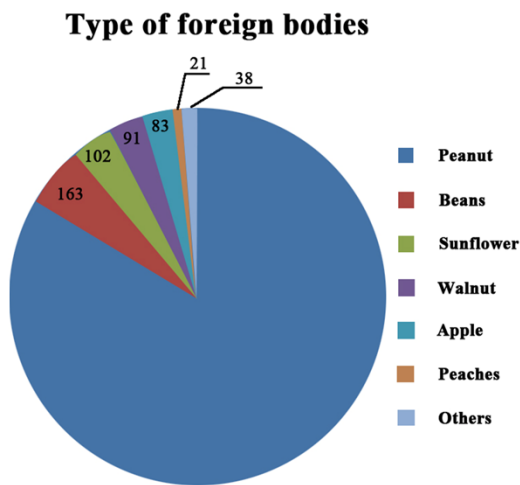


Figure 2. Types of the foreign bodies.

residual TFBs left or if a complication had occurred. All patients were continuously monitored by pluse orimetry and electrocardiography. The vocal cords and trachea were sprayed with lidocaine or tetracaine by direct laryngoscopy. All of the TFBs were removed using rigid bronchoscopy (Stortz) by several forceps. The proper size and length of the instruments were chosen according to the age and weight of each child. The age, gender, type of FBs, location of FBs, radiological findings, complications and outcome were evaluated.

Results

A witnessed inhalation was described in 2899 (95.74%) children. Among the 3028 patients, the FBs were successfully removed by rigid

bronchoscopy without serious complications in 3019 (99.70%) patients. However, a glass ball in one case could not be grasped by rigid bronchoscopy, and thoracotomy was required. Tracheotomy was carried out in 4 patients, including 2 patients with difficulty in extracting the TFBs and 2 patients with laryngeal edema after the operation. Four patients (0.31%) died of FBs in this study. Two patients developed cerebral palsy after the operation. Four patients suffered toxicity from tetracaine during topical an-

esthesia, which included sudden cardiac arrest and other typical local anesthetic complications such as muscular spasm and convulsion. The patients who had symptoms of toxicity were relieved after using some other drugs including diazepam. The age and sex distribution, the type of TFBs and the distribution by seasons are presented in **Figures 1-3**, respectively. The location of TFBs, urban and rural distribution of the patients, the most common symptoms, the most common findings of physical examination, the result of radiologic examination, the complications and outcome of the patients are shown in **Tables 1-7**, respectively. Age and sex distribution of the patients is shown in **Figure 1**. The type of foreign bodies is shown in **Figure 2**. The distribution of seasons is presented in **Figure 3**. The radiologic features of foreign bodies are shown in **Figures 4-7**.

Discussion

TFBs in the airway are one of the major causes of child death, which often affect the children aged 0-4 years [1-7]. Children can't crush peanut, beans and other foods like nuts because of poor chewing function. On the other hand, their protective reflex of throat is insensitive. Thus, children have greater chance to inhale foreign bodies. Older children are curious and may play toys such as the plastic cap of a pen in their mouth, thus they also have greater opportunity to inhale foreign bodies such as caps. Most of the children in our study were younger than 4 years which was similar to previous researches [1-7]. The ratio of boys and girls ranged from

Inhaled foreign bodies pediatric patients of 3028 cases

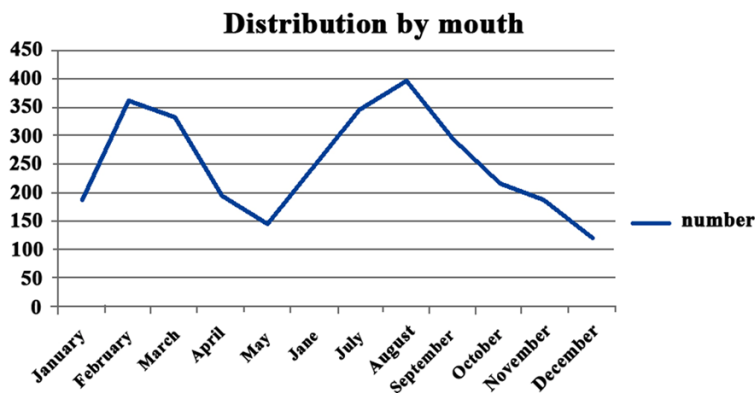


Figure 3. The distribution by seasons.

Table 1. The location of foreign bodies

Location of foreign bodies	Cases	Proportion (%)
Trachea	334	11.03
The right bronchial tree	1703	56.24
The left bronchial tree	974	32.17
Bilateral bronchial trees	15	0.50
Glottal area	2	0.07

Table 2. Urban and rural distribution

Urban and rural distribution	Cases	Proportion (%)
City	301	9.94
Rural area	2727	90.06

Table 3. The most common symptoms

The main symptoms	Cases	Proportion (%)
Cough	2758	91.08
Breathness	2187	72.23
Fever	730	24.11
Cyanosis	99	3.27
Unconsciousness	15	0.49

1.13:1 to 2:1 in previous reports [1-3, 5, 7-9], which was 1.36:1 in our study. It is thought that there are more boys to inhale foreign bodies because they are more active. It was found that the proportion of patients from rural areas (81.6%) was significantly higher compared to those from urban areas (18.4%), which was similar to Abdulazeez's research [6]. On one hand, it is related to the living conditions in rural areas. On the other hand, parents from the rural areas lack the knowledge of scientific feeding, health and safety. According to our data, foreign body inhalation mostly occurs dur-

ing Chinese New Year and the harvest season. Peanuts, melon seeds and other nuts are the main TFB. Children have more opportunity to eat peanuts and other nuts during the period of Chinese New Year and harvest season. Organic substances, such as peanuts, chestnuts, walnuts and beans, are generally found in children younger than 4 years old [1-7]. Plastic substances are observed in older children. In our study, most of the inhaled foreign

bodies were peanuts, accounting for 83.55% of the patients. Majority of the children in our study were from Shandong province of China which was rich in peanuts and children had more chance to eat peanuts. Many articles reported that peanuts were the most common TFBs [1, 2, 4, 5, 7, 10, 11]. Meanwhile, other reports showed that watermelon seeds were the most common FBs found in the airway [9, 12]. Samarei and Murat [6, 8] found that sunflower seeds were mostly observed in children in their study. We found that the types of inhaled foreign bodies were associated with economic conditions. In our study, the common type of TFBs was peanuts and beans in patients before 2000. By contrast, more expensive nuts such as walnuts and chestnuts were found in patients after 2000.

Most researchers [1-10, 13, 14] reported that TFBs were mostly located in the right bronchial tree. A few studies showed that TFBs were mostly observed in the left bronchial tree [11, 15]. The TFBs were incarcerated in the bronchial tree according to their shape and size. The right bronchus is thick and straight, and TFBs are easy to drop into the right bronchus in the first place. But the TFBs are not completely fixed in the airway in the first hours, and the location of TFBs can change from the right bronchial tree to the left one. In our study, we found several patients whose TFBs were located in the right bronchial tree in the outpatient room, and removed their foreign bodies in the left bronchial tree during operation. By contrast, it was found the location of foreign bodies was changed from the left bronchial tree to the right bronchial tree in none patients.

Inhaled foreign bodies pediatric patients of 3028 cases

Table 4. The most common findings of physical examination

Clinical examination	Cases	Proportion (%)
Diminished breath sounds on one side of the chest	2758	91.08
Equale breath sounds	239	7.90
Rhonchi	360	11.89
Rales	301	9.94
Intercostal/suprasternal retraction	69	2.28
Stridor	71	2.34

Table 5. Results of radiologic examination

Fluoroscopy of chest or chest radiography	Cases	Proportion (%)
Pulmonary obstructive emphysema	108	3.57
Pneumonia	508	16.78
Mediastinal swaying	1701	56.18
Pulmonary atelectasis	61	2.01
Pneumothorax	4	0.13
Mediastinal emphysema	2	0.07

Table 6. Complications of the patients

Complication	Cases	Proportion (%)
Pulmonary atelectasis	108	3.57
Pneumonia	508	16.78
Heart failure	10	0.33
Subcutaneous emphysema	4	0.13
Pneumothorax	4	0.13
Mediastinal emphysema	2	0.07
No complications	2392	78.99

It was believed that TFBs located in the right bronchial tree were unstable, which had the opportunity to change their location.

The diagnosis of TFBs is made according to medical history, clinical manifestations and X-ray examination of the lung. The history of foreign body aspiration is of great importance in the diagnosis of TFBs. Many researchers [2, 9, 12] reported that 73.8%-93.2% of their patients had the evidence of foreign body aspiration, consistent with the result of our study (95.74%). The main clinical manifestations of TFBs were cough, shortness of breath, fever and cyanosis. Diminished breath sounds on one side of the chest, rhonchi, rales and three depressions sign were found by physical examination. Radiologic examination (fluoroscopy of the chest or chest radiography) revealed obstructive emphysema, pneumonia, mediastinal swaying, pulmonary atelectasis, mediastinal emphysema and pneumothorax. Diagnosis

by fluoroscopy of the chest or chest radiography is difficult, since it is required that radiologists have rich experience in the diagnosis of TFBs in airway. According to other reports [2, 3, 6, 8, 12], 38%-76% of TFBs were diagnosed correctly by fluoroscopy of the chest or chest radiography. In our study, it was found that 53.7% of the patients were diagnosed by the fluoroscopy of the chest. On the contrary, 601 patients whose results of fluoroscopy of the chest or chest radiography were normal underwent CT scan, and the signs of TFBs were found in 589 patients. The rate of misdi-

agnosis in patients with evidence of foreign body inhalation was significantly low. In our study, 50 patients were diagnosed as bronchopneumonia. One patient had been treated as bronchopneumonia for 10 years until a pen cap located in his bronchus was removed. Therefore, we should pay more attention to the patients whose X-ray findings are normal. Although their results of fluoroscopy of the chest or chest radiography are normal, CT scan of the lung should be provided to the children with the suspected history of foreign body inhalation. CT scan of the lung can directly reveal TFBs through three-dimensional reconstruction. To avoid misdiagnosis, we suggest that the possibility of airway TFBs should be considered under the following conditions: repeated pulmonary infection, localized pulmonary emphysema and pulmonary abscess; cough and shortness of breath; low fever and pulmonary inflammation for a long time.

TFBs in the airway are difficult to be discharged during cough. In the recent 30 years, we only found 23 patients who discharged their TFBs in airway before the operation was carried out, and most of the TFBs were apples and peaches. It was thought that apples and peaches could not cause serious inflammation and were not fixed firmly in the airway. The submucosa tissues of children are loose and it is easy to swell and develop hypoxia. Furthermore, it is more dangerous if the TFBs in the airway are

Table 7. Outcome of the patients

Outcome of the patients	Cases	Proportion (%)
Removal of foreign bodies by the first surgery	2979	98.38
Removal of foreign bodies by the second surgery	40	1.32
Removal by thoracotomy	2	0.07
Cerebral Palsy	2	0.07
Death	4	0.13
Thoracotomy	1	0.03

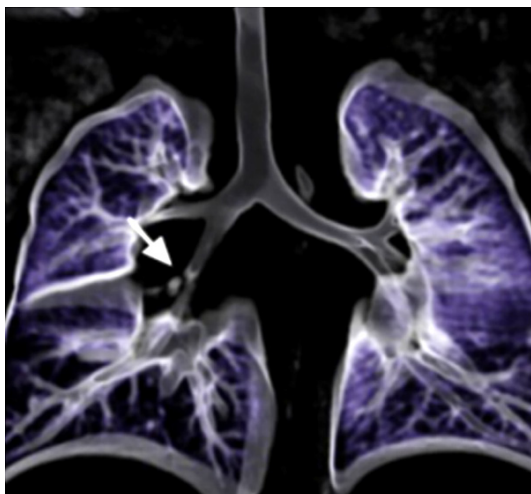


Figure 4. Three-dimensional reconstruction of the lung. The white arrow indicates the foreign body.

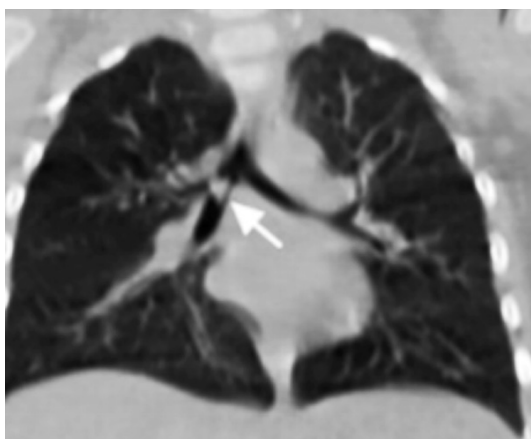


Figure 5. Three-dimensional reconstruction of the lung. The white arrow indicates the foreign body.

not fixed. Therefore, early diagnosis and removal of TFBs are very important for reducing the incidence of complications and mortality. Once the diagnosis is made, the operation should be carried out as soon as possible. Due to the condition of doctors and other reasons, emergency

surgery during the night is more dangerous than operation performed during the work time. Navin Mani [13] reported that the operation was successfully carried out in 92.6% of their patients who were diagnosed as TFBs during the night until work time without complications. Only a few patients needed operation

to remove the TFBs immediately. It is suggested that the TFBs in the trachea and glottal area should be removed immediately because it can cause acute asphyxia. TFBs in the bronchial tree which are inhaled no more than 24 hours should be removed as soon as possible because the TFBs are not fixed and can lead to serious results. The TFBs that are fixed in the bronchial tree can be removed during the work time to avoid emergency surgery during the night. The patients who had serious lung infection and poor general condition should be given systemic treatment before operation. Patients with heart failure should be treated to improve their heart function before operation, if they have no signs of hypoxia. Operation should not be carried out immediately for the patients who have underwent rigid bronchoscopy just a moment ago in other hospitals and have no signs of hypoxia, so as to avoid laryngeal edema and asphyxia due to the repeat stimulus of rigid bronchoscopy. There were 730 patients with fever and 10 patients with heart failure in our study. The patients with heart failure all had serious pulmonary infection induced by TFBs in the bronchial tree. All the patients were treated with anti-infection therapy and underwent rigid bronchoscopy successfully without complications. There were 4 cases with pneumothorax caused by TFBs in the airway in our study. Increased pulmonary pressure caused by the TFBs was the main reason of pneumothorax.

Rigid bronchoscopy is one of the best ways to remove TFBs. The choice and inspection of suitable surgical instruments are of great importance for the success of the procedure. Different forceps should be chosen by the types and characteristics of foreign bodies. Spare equipments should be ready in case of damage. The fixed TFBs in the trachea and the bronchial tree should be removed by rigid bronchoscopy. Big or irregular TFBs in the trachea can be removed under the direct laryngo-

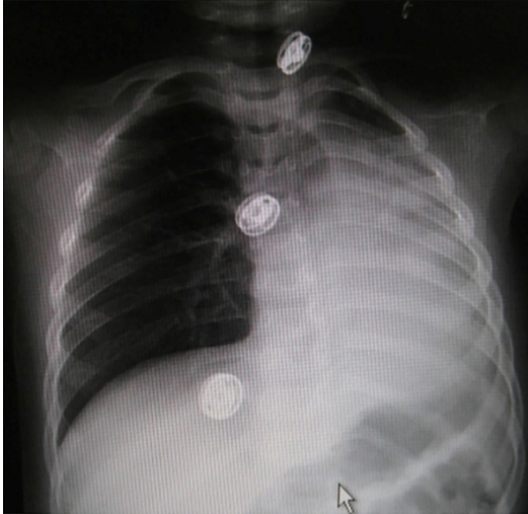


Figure 6. Atelectasis.

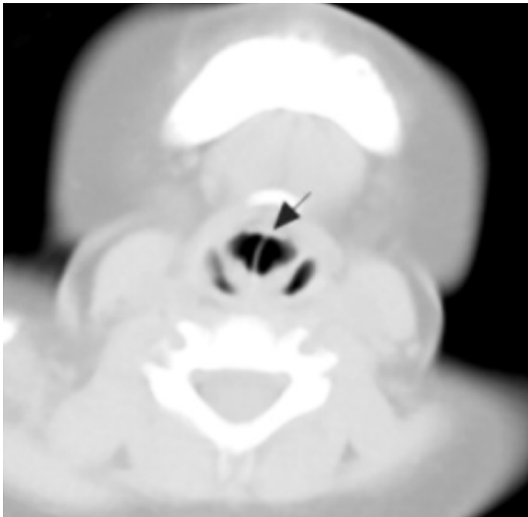


Figure 7. The black arrow shows the foreign body in the vocal area.

scope by grasping forceps. The sunflower seeds in the trachea were removed by rigid bronchoscopy or direct laryngoscopy without tracheotomy in 93 patients in our study. If the TFBs such as peanuts were fragile, the forceps should be used to grasp them as much as possible with appropriate force to avoid crushing them. After grasping TFBs, the bronchoscope and forceps should be fixed relatively, and they were withdrawn together. It was important to adjust the direction of forceps before the bronchoscope and pliers were pulled through the glottis. Rigid bronchoscopy should be performed again soon after removal of the TFBs to confirm no residual

or fragments of TFBs in the tracheobronchial tree under the condition of no life threatening risk. Laryngeal edema may be developed if rigid bronchoscopy was performed repetitively. In our opinion, the examination should be carried out no more than 5 times in order to avoid laryngeal edema. On the other hand, dexamethasone or methylprednisolone was prescribed during operation to avoid laryngeal edema. After the operation, patients with dyspnea should be treated with tracheal intubation. The trachea cannula was extracted after the patient was stable. The children who had serious pulmonary infection should be treated by local douche in order to reduce inflammation of the location where the TFBs were located. If the atelectasis affected the lung where the TFBs were located, it was very difficult to remove the TFBs because of the negative pressure in the lung. It was recommended to spray adrenaline around the TFBs in order to reduce the edema of mucosa and let the air enter the lung. The TFBs tended to fall into the contralateral bronchus and caused acute asphyxia during the process of removal. Therefore, it was necessary to ensure that the TFBs were clamped firmly during the procedure.

Patients with unconsciousness and acute obstruction of respiratory tract must be treated by rigid bronchoscopy immediately. Under the circumstance, rigid bronchoscopy can be carried out under general anesthesia or no anesthesia. The foreign bodies must be removed quickly and cardiopulmonary resuscitation was prepared. If it was difficult to remove the FBs immediately, anesthesiologist should carry out tracheal intubation to supply the patients with oxygen. When the situation of the patient became stable, bronchoscopy can be performed again to remove TFBs. We had ever met 15 cases who came to our hospital with unconsciousness and acute obstruction of respiratory tract. In the 15 cases, bronchoscopy was carried out immediately and the TFBs were removed in 14 cases. One patient died of hypoxia.

It is still necessary to perform tracheotomy under particular conditions. The TFBs should be removed through the tracheostoma if it was too big to pass through the glottis. Tracheotomy should be performed on the patients with serious laryngeal edema after operation, which

was particularly important for the doctors in the primary health care institutions. In recent years, endotracheal intubation was carried out on patients with laryngeal edema and the chance of tracheotomy was reduced. In our study, tracheotomy was performed on 2 patients to remove the TFBs, which was performed on another two patients due to serious laryngeal edema after the operation.

The anesthesia of patients with TFBs is critical in the procedure of rigid bronchoscopy. If the choice of anesthesia was not appropriate, stimulation from the rigid bronchoscopy during the examination may lead to laryngospasm, bronchospasm, respiratory arrest and even cardiac arrest. In the early stage, it was argued that the operation could be performed under surface anesthesia with 1% tetracaine. Now general anesthesia with autonomous respiration is recommended. Ketamine may induce laryngospasm, bronchospasm and cardiac arrest, so it was not recommended. According to our experience, rigid bronchoscopy under deeper general anesthesia was safer than that under lighter one. In our study, diazepam and γ -hydroxybutyrate sodium combined with adequate surface anesthesia of local mucosa were prescribed during the operation. There were few serious complications during the operation. There were 12 cases developing laryngeal edema after rigid bronchoscopy.

The mortality of TFBs ranged from 0.21% to 3% according to other studies [2, 5, 12], which was 0.13% in our study. According to our experience, it was found that the younger the patients were, the higher the risk was. There were 4 patients (0.13%) who died of hypoxia in our study. Of these patients, one patient died of laryngeal edema, and one died of delayed surgery (her parents refused tracheotomy after rigid bronchoscopy). Two patients died of airway obstruction, whose foreign bodies were dry beans. The mortality of patients with beans in the airway was highest due to swelling of the beans. Plastic whistles were thin-walled and hollow, and they were removed successfully in the first attempt in 9 cases. On the contrary, it was very difficult to remove the pen cap from the bronchus because of negative pressure in the lung caused by TFBs. Pen caps were ever removed successfully in 4 cases. Firstly 1‰ adrenaline was sprayed around the pen

cap to mitigate the edema of mucosa and the pen cap was rotated to let air enter the lung. Some patients had hyperresponsiveness of airway, and they presented with wheezing after inhaling TFBs. For these patients, the effective treatment was immediate removal of the TFBs. We had met 9 cases with serious wheezing. It was difficult to maintain oxygen saturation of the patients during the operation. Endotracheal intubation was performed and muscle relaxant drugs were provided before removing the TFBs.

In our study, rigid bronchoscopy was carried out once again in 40 patients. Nothing was found in the airway in 7 patients during the first examination. The foreign bodies were not completely removed in 16 cases during the first examination. TFBs were found but cannot be removed in 17 patients, who required the examination once again. The doctor's skills and experience in dealing with such cases were very important. The type and location of TFBs also accounted for the second examination. The ENT doctor could not find the foreign bodies which were wrapped by granulation tissue in 6 cases during the first examination. The TFBs were pushed to the distal segment of the bronchus in 16 patients during the first examination. It was suggested that the procedure of rigid bronchoscopy should be performed by ENT specialists with rich experience in the management of TFBs. If granulation tissue was found in the bronchus, it should be checked carefully.

Prevention of TFBs is very important in children under 4 years old, therefore the education of their parents should be emphasized. The fatality of TFBs should be well-publicized to everyone as possible, especially in rural areas. The children should be forbidden running or jumping when eating nuts to avoid TFBs inhalation. Doctors should be familiar with clinical diagnosis and treatment of TFBs.

Conclusion

Rigid bronchoscopy under general anesthesia combined with adequate surface anesthesia of local mucosa is a very safe and effective way in the management of foreign body aspiration, which should be carried out by skilled ENT specialists and anesthetists. In the management of TFBs, the ENT specialists, anesthetists, radiologists and pediatricians should try their best to reduce the disability and mortality through

Inhaled foreign bodies pediatric patients of 3028 cases

in-depth cooperation. What's more, it is necessary to pay more attention to the prevention of foreign body aspiration.

Disclosure of conflict of interest

None.

Address correspondence to: Dr. Na Li, Department of Otorhinolaryngology Head and Neck Surgery, The Affiliated Hospital of Qingdao University, No. 16, Jiangsu Road, Shinan District, Qingdao 266-003, Shandong Province, China. Tel: +86+0532-82911346; E-mail: lnanihao@163.com

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