

Management of Foreign Body Aspiration in Children: Insights From 664 Cases in the Operating Room

Author(s)

**Sibel Seçkin Pehlivan¹, Özlem Öz Gergin¹, Ebru Sönmez¹,
Adnan Bayram¹, Recep Aksu¹, Ömer Önal², Cihangir Biçer¹**

Affiliation(s)

¹Erciyes University Faculty of Medicine, Department of Anaesthesiology and Reanimation, Kayseri, Turkey

²Erciyes University Faculty of Medicine, Department of Thoracic Surgery, Kayseri, Turkey

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Abstract

Tracheal or bronchial foreign body aspiration is an important emergency of childhood requiring bronchoscopy under general anesthesia. In this retrospective study, bronchoscopy were performed for foreign body aspiration; anesthesia methods, risks, and postoperative complications were evaluated. Children who underwent bronchoscopy with suspicion of a foreign body in the pediatric surgery operating room between January 2010 and December 2021 were included in the study. Six hundred and sixty four children were evaluated. General anesthesia was applied to all bronchoscopy. Demographic characteristics of the patients, type of foreign body, localization of foreign body, distribution of foreign body according to age groups, complications related to anesthesia and surgical process, length of stay in the postoperative intensive care unit, and duration of hospital stay were evaluated. The patients who aspirated foreign bodies most frequently were children aged 1-3 years (73.6%). During bronchoscopy, organic matter (seeds, hazelnuts, peanuts, chickpeas) was the most frequently removed foreign body in children (559 patients). It was observed that foreign bodies were mostly located in the right main bronchus at a rate of 52.4%, the left main bronchus at 28%. The most common anesthesia-related complications were desaturation in 400 patients, hypercarbia in 200 patients, bronchospasm in 108 patients, and respiratory arrest in 2 patients. Many problems may be encountered in foreign body inhalation, and bronchoscopy of these patients should be performed by an experienced anesthesiologist and surgeon at the right time and in the safest way in terms of anesthesia and surgery.

Keywords: Anaesthesia, foreign body aspiration, rigid bronchoscopy



Correspondence: Sibel Seçkin Pehlivan, Erciyes University Faculty of Medicine, Department of Anaesthesiology and Reanimation, Kayseri, Turkey

E-mail: sibelpehlivan@erciyes.edu.tr **ORCID:** 0000-0003-3215-5616

Introduction

Foreign body aspiration in infants and children is an emergency surgical procedure that can be fatal.¹ Anamnesis of the family or the patient, rapid diagnosis, and bronchoscopy are lifesaving. Bronchoscopy is the gold standard for the diagnosis and treatment of foreign bodies. Flexible bronchoscopy successfully removes foreign bodies in the subsegments; however, because it requires sedation, cooperation might be challenging in children.^{2,3} Rigid bronchoscopy is performed in the operating room under general anesthesia. Oxygenation and ventilation problems may occur due to joint use of the airway with the anesthesiologist and the clinician performing bronchoscopy.^{4,5} Different ventilation methods (controlled and spontaneous ventilation) can be applied according to the experience of the anesthesiologists and hospital protocols.⁶ The disadvantage of spontaneous ventilation is that the foreign body can be displaced by airway reflexes (cough, laryngospasm, or bronchospasm).⁵ Adequate depth of anesthesia for a rigid bronchoscope can be achieved using muscle relaxants.⁷ Positive pressure ventilation reduces atelectasis and increases oxygenation.⁴

Foreign body aspirations are a serious health problem that can lead to fatal outcomes in childhood. According to the literature, although most deaths occur before admission to the hospital, anesthesia management and bronchoscopy procedures are also important causes of mortality and morbidity. However, there is still no consensus on the optimal anesthesia technique in the literature. In this article, we wanted to update and share our anesthesia methods for rigid bronchoscopy in foreign body aspiration, which is an important problem in childhood.

Materials and Methods

In this retrospective study, 664 pediatric patients aged 0-18 years who came to our hospital with a diagnosis of a foreign body and underwent rigid bronchoscopy were evaluated in terms of age, gender, type of foreign body, localization, and complications observed during and after the procedure. After obtaining study permission from the Erciyes University Clinical Research Ethics Committee (decision no: 2022/381, date: 11.05.2022), the data obtained by scanning the files over the electronic information systems in our hospital were evaluated.

Patients who had a history of cardiopulmonary arrest before bronchoscopy and whose files were missing any datum planned to be evaluated were not included in the study. Demographic characteristics of the patients, type of foreign body, localization of foreign body, distribution of foreign body according to age groups, complications related to anesthesia and surgical process, length of stay in the postoperative intensive care unit, and duration of hospital stay were evaluated.

In the presence of findings such as acute asphyxia, radiopaque foreign body presence, unilateral decreased respiratory sound, mediastinal shift, or emphysema in patients who came to our clinic with foreign body aspiration, the procedure was performed under general anesthesia without premedication because rigid

bronchoscopy was indicated. General anesthesia was administered without premedication in patients admitted to our clinic with tracheal bronchial foreign body aspiration. Before the intervention, electrocardiograph, oxygen saturation, and non-invasive blood pressure were monitored. Anesthesia induction was performed with propofol 2-3 mg/kg intravenous (IV) in the presence of 100% oxygen or with 4-5% sevoflurane if there was no vascular access. Rocuronium 0.6-1.2 mg/kg IV was administered to prevent the airway reflex in the patient. Intraoperative ventilation was continued manually with 4-6 l/min 100% oxygen by attaching the breathing circuit to the ventilation section of the rigid bronchoscope. In the maintenance of anesthesia, 2% sevoflurane-100% oxygen and remifentanyl were provided with 0.1-0.2 $\mu\text{g kg}^{-1} \text{min}^{-1}$ or with longer-acting fentanyl (1 $\mu\text{g kg}^{-1}$). Manual ventilation was intermittently interrupted in coordination with the bronchoscopist and apnea periods and oxygen insufflation were performed. The trachea and main bronchi were re-checked for possible complications after the foreign body was removed with forceps. When the procedure was completed, anesthetic drugs were discontinued and muscle relaxants were antagonized. The patient's spontaneous respiration was supported with 100% oxygen until it reached a sufficient level. Patients with respiratory distress received 1 mg/kg lidocaine or 1 mg/kg methylprednisolone. Patients with respiratory distress, despite medical treatment, were treated in the intensive care unit by endotracheal intubation. At the end of the procedure, patients without respiratory distress were transferred to the recovery unit, and patients with an Aldrete recovery score⁸ of ≥ 9 were sent to their rooms in the thoracic surgery ward.

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS) v.26.0 (IBM Corp. Armonk, NY, USA) package program was used for the statistical analysis of the study. Compliance of numerical data with normal distribution was evaluated using the Shapiro-Wilk test in each group. Those who did not show a normal distribution were evaluated using the Mann-Whitney U test, and categorical data were evaluated using the chi-square exact test. The homogeneity of variances was evaluated using Levene's test.

Numerical variables are given as mean standard deviation, and categorical variables are given as frequency (percentage). Relationships between categorical variables were evaluated by chi-square analysis, and $p < 0.05$ was accepted as sufficient for statistical significance in testing two-way hypotheses.

Results

Between January 2010 and December 2021, 664 patients underwent rigid bronchoscopy with the suspicion of foreign body aspiration in the thoracic surgery operating room of Erciyes University Medical Faculty. The mean age of the patients was two years. Of these, 415 (62.5%) were male and 249 (37.5%) were female. Foreign bodies were detected in 612 (92.1%) of 664 patients (**Table 1**). The average procedure duration was 52 minutes.

The patients who most frequently aspirated foreign bodies were children aged 1-3 years (73.6%) (Table 2). Among these, the number of children in the 1-year age group was high (55.9%). The distribution of foreign body type by the age group is given in Table 3. In the distribution of gender by the age group, the number of males was significantly higher than that of females ($p < 0.05$). During bronchoscopy, organic matter (seeds, hazelnuts, peanuts, chickpeas) was the most frequently removed foreign body in children (559 patients). In contrast, inorganic substances such as toys and pencils were found more frequently in children over school age. Pin aspiration was among the aspirated inorganic materials, especially in female patients who wore headscarves.

It was observed that foreign bodies were mostly located in the right main bronchus at a rate of 52.4%, the left main bronchus at 28%, and the trachea at 7.8%. It was observed that it was in both lungs with a rate of 3.4% and outside the respiratory system with a rate of 0.6% (Table 4). Foreign body aspiration was outside the respiratory tract in 4 patients. One was located in the esophagus, one in the epiglottis, one in the mouth, and one in the vocal cords.

Of the 664 patients who underwent bronchoscopy, 605 did not require intensive care (91.1%). Of the patients

staying in the intensive care unit, 13 remained in the intensive care unit for more than one week (Table 1).

The most common anesthesia-related complications were desaturation ($SpO_2 < 95\%$) in 400 (60.2%) patients, hypercarbia in 200 (30.1%) patients, bronchospasm in 108 (16.2%) patients, and respiratory arrest in 2 patients (0.4%). There were 4 (0.6%) pneumothorax, three bleeding (0.5%), one pneumomediastinum (0.2%), and 3 (0.5%) open surgery requirements. Complications related to the rigid bronchoscopy procedure were also observed. Because of the development of cardiac arrest during the procedure, one patient was resuscitated by cardiopulmonary resuscitation, but the patient died after 24 h during intensive care follow-up (Table 5).

Highlights

- Foreign body aspiration in infants and children is an emergency surgical procedure that can be fatal.
- Bronchoscopy is the gold standard for the diagnosis and treatment of foreign bodies.
- Rigid bronchoscopy is performed in the operating room under general anesthesia oxygenation and ventilation problems may occur due to joint use of the airway with the anesthesiologist and the clinician performing bronchoscopy.

Discussion

In this retrospective study, we evaluated 664 patients who met the study criteria perioperatively and underwent rigid bronchoscopy due to

suspicion of foreign body aspiration in Erciyes University Hospitals between 2010-2021.

Foreign body aspiration is especially common in boys under the age of 3.² In this age group, curiosity about the objects in the environment, taking the objects to their mouth to recognize the object, and talking and laughing when there is an object in the mouth due to the anatomically underdeveloped larynx and epiglottis cause aspiration.⁹ Aspirated foreign bodies may differ from country to country. Paksu et al.¹⁰ reported that under the age of 3 years, organic body aspiration was higher, and for those above the age of 3 years, inorganic body aspiration was higher. In our study, although the inorganic body aspiration was not statistically

Table 1.

Demographic datas

Age (years) (mean \pm SD)	2.09 \pm 3.01
Gender, n (%)	
Female	249 (37.5)
Male	415 (62.5)
Foreign body detected, n (%)	
Yes	612 (92.1)
No	52 (7.9)
Duration of bronchoscopy (minutes)	52 \pm 2.9
Hospital stay (days) (med, min-max)	2.31 (0-39)
Need for intensive care n (%)	
Yes	59 (8.9)
No	605 (91.1)

SD; Standard deviation, Min-max; Minimum-maximum
Parameters are presented as mean \pm standard deviation or n (%)

Table 2.

Gender distribution by age groups

	Female	Male	Total	p
0-1 years	38 (5.8)	50 (7.5)	88 (13.3)	-
1-3 years	170 (25.6)	319 (48)	489 (73.6)	-
4-6 years	13 (1.9)	23 (3.4)	36 (5.3)	-
7-10 years	13 (1.9)	9 (1.4)	22 (3.3)	-
10-18 years	15 (2.2)	14 (2.3)	29 (4.5)	-
Total	249 (37.4)	415 (62.6)	664 (100)	0.046

Parameters are presented as n (%), $p < 0.05$, significant difference

Table 3.

Distribution of foreign body type by age groups

	Organic n (%)	Inorganic n (%)	p
0-1 years	66 (11.8)	7 (13.1)	-
1-3 years	445 (79.6)	18 (34)	-
4-6 years	26 (4.7)	8 (15.1)	-
7-10 years	8 (1.4)	10 (18.9)	-
10-18 years	14 (2.5)	10 (18.9)	-
Total	559 (100)	53 (100)	0.001

Parameters are presented as n (%), $p < 0.05$, significant difference

Table 4.

Foreign body localization

	n (%)
Right bronchial tree	348 (52.4)
Left bronchial tree	186 (28)
Trachea	52 (7.8)
Double lung	22 (3.4)
Outside the respiratory tract	4 (0.6)

Parameters are presented as n (%)

Table 5.
Peri-interventional complications

	n (%)
Complications related to anesthesia	
Desaturation	400 (60.2)
Hypercarbia	200 (30.1)
Laryngospasm	108 (16.2)
Arrest	2 (0.4)
Complications related to bronchoscopy	
Pneumothorax	4 (0.6)
Bleeding	3 (0.5)
Pneumomediastinum	1 (0.2)
Transition to open surgery	3 (0.5)
Cardiac arrest	1 (0.2)

Parameters are presented as n (%)

significantly higher in school-age children aged 7-10 years, the number was higher. However, organic body aspiration was statistically high in children under 3 years of age.

Bronchoscopy is the gold standard for diagnosing and treating foreign body aspiration.¹¹ The mortality rate in bronchoscopy has been reported to be 0.42%.¹² Factors affecting mortality can be described as hypoxia developing before or after bronchoscopy, age of the child, type of foreign body, inflammation, duration of inflammation, and complications that may develop during anesthesia and the procedure.¹³ Therefore, it would be ideal to perform rigid bronchoscopy when the foreign body aspiration is suspected. Flexible bronchoscopy are preferred for small-diameter foreign bodies.¹⁴⁻¹⁶

The time of bronchoscopy may also affect mortality and morbidity. In patients whose fasting period has not expired but who have respiratory distress, aspiration forms the basis of complications that may develop. When patients are respiratory stable, it is ideal to perform bronchoscopy in daytime conditions where experienced anesthesiologists and surgeons are present in the most suitable conditions regarding anesthesia and the procedure.¹⁷ In our clinic, if the patient does not have respiratory distress and the foreign body is located in an area that does not cause a problem, we aim to wait for the appropriate time to remove the foreign body to reduce the complications that may develop.

In patients presenting with suspected foreign body aspiration, clinical findings differ according to the location of the foreign body.¹⁸ While cough is the most common reason for admission, wheezing and respiratory distress are the following findings.² The most common hospital admission symptoms in our study were cough, wheezing with sudden onset, cyanosis, and vomiting. The literature recommends bronchoscopy in suspected foreign body aspiration cases.¹⁹ Şahin et al.² reported the rate of negative bronchoscopy as 24.6% in 28 cases. Pan et al.²⁰ reduced this rate from 18% to 4% because they performed fiberoptic bronchoscopy before rigid bronchoscopy. It is stated in studies that the rate of negative bronchoscopy varies between 14% and 22.3%. Negative bronchoscopy was found in 52 (7.9%) of 664

patients in our study. Our negative bronchoscopy rate is quite low compared with the literature. The reason for this result is that the diagnosis is established by flexible bronchoscopy performed under sedation in children who were clinically stable and whose diagnosis could not be supported by chest X-ray or tomography. However, routine fiberoptic bronchoscopy was not performed before rigid bronchoscopy.

There is no definite consensus regarding the premedication to be administered to patients who will undergo rigid bronchoscopy.^{21,22} Midazolam may increase respiratory distress because of its sedative and respiratory depressant effects. It is not easy to share the airway with a surgeon during bronchoscopy. Therefore, general anesthesia would be a good choice for foreign body aspirations. Some studies have stated that spontaneous breathing and propofol-remifentanyl anesthesia might delay cough, apnea, body movement, and awakening during the removal of the foreign body.⁴ We used the short-acting rocuronium as a muscle relaxant to reduce the complications arising from manipulations during the removal of the foreign body with the combination of propofol-fentanyl or remifentanyl. Rocuronium is an agent that acts more rapidly in children, and its effect ends quickly.⁴

Corticosteroids are recommended before or during bronchoscopy to reduce inflammation and subglottic edema in the airway.¹⁸ However, there is no consensus on the timing of corticosteroid administration. Li et al.²² administered methylprednisolone as a prophylactic agent before induction. Apa et al.¹⁹ initiated steroid treatment before bronchoscopy and administered steroid infusion for 24 h. Zhang et al.²³ suggested intraoperative methylprednisolone or dexamethasone treatment. In our clinic, a 1 mg/kg dose of methylprednisolone is administered intraoperatively, and laryngospasm and bronchospasm that might develop are prevented.

Because the right main bronchus is wider, shorter, and more vertical than the left main bronchus, the incidence of foreign bodies in the right bronchial system is more common. However, according to the literature, the incidence of foreign bodies is equal in the right and left bronchi because the bronchi protrude from the trachea at an equal angle in early childhood.²⁰ Cohen et al.¹⁴ reported that foreign body aspiration is most common in the left main bronchus. In our clinic, contrary to the literature, foreign bodies were observed in the right and left bronchial systems at a rate of 52.4% and 28%, respectively.

Complications due to anesthesia or the procedure that may result in mortality may develop during bronchoscopy.² Studies reported that the most common complication due to anesthesia was laryngospasm.²⁴ Laryngospasm might be caused by preoperative respiratory distress, degree of airway obstruction, depth of anaesthesia and stress-related factors.²⁵ Qiu et al.⁴ reported the rate of laryngospasm development as 0.6% in their study consisting of 2886 patients under ten years of age, but this rate was 16.2% in our study. Although propofol and muscle relaxants were used for anesthesia it was thought that the reason for this finding might be mucosal damage during the removal of the foreign body

and the long duration of the procedures. In 3 patients, the foreign body could not be removed by bronchoscopy, and thoracotomy was performed.

The mortality rate due to rigid bronchoscopy was 0.42%. In our clinic, two patients had an arrest after desaturation due to the foreign body's complete obstruction of the trachea during the procedure, which was reversed with resuscitation. However, one patient had sudden cardiac arrest due to bronchial rupture during the procedure and died within 24 h in the intensive care unit after resuscitation. The duration of hospital stay may vary according to the economic conditions and hospital policies in the literature. In the study of Qiu et al.⁴, the average hospital stay was two days, whereas it was 2.3 days in our study.

Conclusion

Foreign body aspiration is a severe condition that can be fatal to childhood. Although it can be seen in all age groups, it is more common under the age of 3 years. Both rigid bronchoscopy and anesthesia management for diagnosis and treatment require experience. Over time, developments in anesthesia and bronchoscopy have contributed positively to the management of foreign body aspiration. There is no clear consensus on the ideal anesthesia management and premedication among various anesthesia techniques. As long as the hemodynamics of the patients are stable, it is recommended to perform bronchoscopy under elective conditions. In patients scheduled for bronchoscopy with suspected foreign body aspiration, the anesthesiologist and the team that will perform the bronchoscopy should be in close cooperation. This cooperation and teamwork should be considered the most important factor affecting the success of the process.

Although our study is retrospective, applying the anesthesia protocol accepted in our clinic in the anesthesia management of all patients increases the reliability of our results. However, we believe that prospective studies with more extensive patient series are required.

Ethical Approval: After obtaining study permission from the Erciyes University Clinical Research Ethics Committee (decision no: 2022/381, date: 11.05.2022), the data obtained by scanning the files over the electronic information systems in our hospital were evaluated.

Informed Consent: Because the study was designed retrospectively no written informed consent form was obtained from the patients.

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