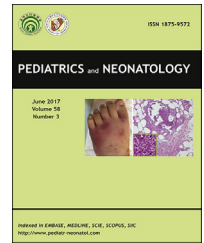




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ORIGINAL ARTICLE

A Diagnostic Dilemma for the Pediatrician: Radiolucent Tracheobronchial Foreign Body



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Key Words

aspiration;
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foreign bodies

Background: The purpose of this study is to determine the role of clinical history, physical examinations, and radiological findings in the evaluation of patients with suspected radiolucent foreign body aspiration.

Methods: The medical records of 236 children (under the age of 18 years), on whom a rigid bronchoscopy was performed between 1999 and 2015 because of suspected radiolucent foreign body aspiration, were analyzed retrospectively. Sensitivity, specificity, positive and negative predictive values of clinical history, physical examinations, and radiological findings were evaluated.

Results: In 71.1% of all cases, the children were under the age of 3 years. The bronchoscopy showed the presence of a foreign body in 52.9% of cases, with the locations of the foreign bodies being as follows: (1) right main bronchus, 47.2%; (2) left main bronchus, 36.0%; (3) trachea, 11.2%; (4) both bronchi, 5.6%. Organic foreign bodies were found in 78% of the patients, whereas inorganic foreign bodies were detected in 22% of the patients. The sensitivity and specificity of clinical history, physical examinations, and radiological findings were 98.4% and 54.9%, 47.2% and 74.7%, and 35.2% and 92.7%, respectively.

Conclusion: Tracheobronchial foreign body aspirations usually occur prior to the age of 3 years, with the most frequently aspirated foreign bodies being food or items of a radiolucent nature. Clinical history, physical examinations, and radiological findings are not able to detect the presence of a radiolucent foreign body aspiration in children. Therefore, a bronchoscopy should be performed on children in whom a choking event has been witnessed, even in cases of normal radiological and clinical findings.

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1. Introduction

Foreign body aspiration (FBA) in the tracheobronchial system is a life-threatening condition and results in the death of eight patients every day in the USA. Radiopaque foreign bodies can easily be detected in chest X-rays and simplifies the decision to perform a bronchoscopic examination. Unfortunately, most aspirated foreign bodies are radiolucent and frequently of food origin. Approximately 80% of all patients are aged younger than 15 years, with a peak prior to the age of 3 years.^{1–3} Within this age group, commonly encountered diseases that may have similar symptoms and clinical findings—such as pneumonia, croup, or asthma—present a challenge for the clinicians in terms of deciding whether or not to perform a bronchoscopy. Indications for performing a bronchoscopy for radiolucent foreign bodies in cases of suspected FBA are still a matter of debate in many centers, as positive bronchoscopy rates range between 57% and 96.3% in large series.^{4–6} Clinical presentations may vary, from no obvious symptoms to severe respiratory distress and asphyxia, according to nature, site, location, and the duration of the foreign body, and can also depend on the stage at which the patient presents. Although aspiration of the foreign body or a choking episode in the clinical history, one that has been witnessed by an adult or remembered by the child themselves, is the most suggestive presentation, obscure physical or radiological findings of an unwitnessed FBA requires a meticulous, systematic assessment that includes all findings and a detailed medical history in order to avoid unnecessary bronchoscopies and to prevent the overlooking of an FBA in the tracheobronchial tree.^{7,8}

This study aims to evaluate the efficient value of the clinical history, physical examinations, and radiological findings in detecting radiolucent foreign bodies located in the tracheobronchial tree prior to performing a bronchoscopy and to analyze bronchoscopy results, with regard to aforementioned findings, for suspected FBA.

2. Materials and methods

After obtaining approval from the ethics committee of the institution, a retrospective analysis was carried out in a tertiary care hospital between 1999 and 2015 on the medical records of 236 children (under the age of 18 years), on whom a rigid bronchoscopy was performed because of suspected FBA. The exclusion criteria used for the study included: (1) children with radiopaque foreign bodies in the tracheobronchial tree detected with chest radiographs; (2) patients with foreign bodies confirmed by flexible bronchoscopies performed in different departments; and (3) patients whose parents or legal guardians refused to sign the informed consents. Data regarding age, sex, type of foreign body, history of a choking episode (sudden onset of paroxysmal coughing, gagging, acute respiratory distress, cyanosis), physical examination findings (cough, tachypnea, use of accessory muscles of respiration, stridor, abnormal/decreased breathing), and secondary radiological findings (localized hyperlucency/obstructive emphysema, hyperexpansion, atelectasis, pneumonia, mediastinal shift, pneumothorax/pneumomediastinum) of the patients, along

with the properties and location of the foreign bodies as well as any complications, were recorded. On all patients with suspected FBA, upright posteroanterior and lateral chest radiographs (including the neck region) were performed in the emergency department, the results of which were evaluated by an experienced pediatrician or a pediatric surgeon. In our institution, all patients with suspected FBA underwent a rigid bronchoscopy for the purpose of both diagnosis and treatment during the same session. All bronchoscopy procedures were performed by a pediatric surgeon in the operating room, where the patient was placed under general anesthesia and controlled ventilation by an anesthetist. Throughout the procedures, the cardiac rhythm, oxygen saturation, noninvasive blood pressure, and electrocardiogram of the patients were monitored. For bronchoscopy procedures, a 2.5-mm to 4.5-mm (inner diameters were 3.5 mm, 4.3 mm, 5.0 mm, 6.2 mm, and 6.6 mm) Doesel–Huzly rigid bronchoscope, a 0° Hopkins straightforward optic telescope (Karl Storz Co., Tuttlingen, Germany), and a video system were used, in accordance with the age and size of the child. Assisted or controlled ventilation was executed via a circuit connected to the lateral side of the rigid bronchoscopes. Depending on the nature and physical shape of the foreign bodies, different types of mounted optical foreign body forceps (10378 HF, 10378 CF, 10378 KF; Karl Storz Co.) were used for extraction. Particularly in cases of longstanding foreign bodies, if bleeding of granulation tissue occurred during the attempt to extract the foreign body, the procedure was completed by attaining better visualization in the second or third repeat session of the bronchoscopy. After extracting the foreign body, all patients were checked for residual fragments, contralateral foreign bodies, or any iatrogenic injuries. A plain chest radiography was performed in the operating room on all patients after completion of the procedure for determination of possible pneumothorax or pneumomediastinum. After the removal of the foreign bodies, the patients were separated into two groups: organic and inorganic.

3. Results

The study population included a total of 236 patients: 133 (56.4%) male children and 103 (43.6%) female children, all of whom were between the ages of 3 months and 16 years (mean age, 34.8 ± 38.7 months). Among these patients, 168 (71.1%) were between the ages of 0 years and 3 years, 33 (13.9%) were between 3 years and 5 years, and 35 (14.8%) were older than 5 years (Table 1). There were no underlying diseases present that could have been responsible for aspiration such as cerebral palsy and bedridden or psychomotor retardation in the study group.

The bronchoscopy showed a foreign body in 125 (52.9%) of the 236 patients with suspected FBA. A second and third bronchoscopy were required to be performed because of unclear imaging attained as a result of bleeding of the inflamed granulation tissue during the attempt to extract distally located longstanding peanuts in two patients. All foreign bodies were extracted with bronchoscopic procedures, and no patient required a thoracotomy or tracheostomy for a retained foreign body.

Table 1 Demographic data of children with suspected foreign body aspiration.

		Age (y)			Sex	
		0–3 (n = 168)	3–5 (n = 33)	5–18 (n = 35)	Female (n = 103)	Male (n = 133)
Foreign body negative		81	7	23	44	67
n = 111 (47.03%)		87	26	12	59	66
Foreign body positive	Inorganic	8	14	5	12	15
n = 125 (52.97%)	n = 27 (21.6%)					
	Organic	79	12	7	47	51
	n = 98 (78.4%)					
Location of foreign body	Right	42	11	6	27	32
(n = 125)	n = 59 (47.2%)					
	Left	38	5	2	22	23
	n = 45 (36%)					
	Trachea	3	7	4	6	8
	n = 14 (11.2%)					
	Bilateral	4	3	—	4	3
	n = 7 (5.6%)					

The locations of foreign bodies, along with the corresponding number of patients, were as follows: (1) right main bronchus, 59 (47.2%); (2) left main bronchus, 45 (36.0%); (3) trachea, 14 (11.2%); (4) both bronchi, 7 (5.6%; [Table 1](#)). Organic foreign bodies, such as pistachios, peanuts, hazelnuts, pumpkin, sunflower and watermelon seeds, and fruit/vegetable particles (cucumber, carrot, apple) were found in 98 (78.4%) of the patients. Inorganic foreign bodies, including fragments of plastic toys, pen caps, rubber fragments, small stones, balloons, and nylon covers of different objects, were detected in 27 (21.6%) of the patients.

Each parameter (clinical history, physical examination findings, and radiological findings) was analyzed for sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) for indication of FBA. A positive choking history, including sudden onset of respiratory distress while eating or playing with a toy, was reported by an adult or a child themselves in only 173 (73.3%) patients. The foreign body was detected in 123 (71%) of 173 children with a positive choking history, whereas foreign bodies were detected in two (3.1%) of 63 children without any choking history. The sensitivity and specificity of choking history were 98.4% and 54.9%, respectively, whereas the PPV and NPV for the same parameter were 71% and 96.8%, respectively.

There were no physical examination findings in 66 (52.8%) positive bronchoscopy cases. However, a positive physical examination finding was observed in 28 of 111 (25.2%) negative bronchoscopy cases. In only 59 out of 125 (47.2%) patients, a positive physical examination finding was present. Locally decreased respiratory sounds, the most common physical examination finding, was present in 47 (37.6%) of these patients. Use of accessory muscles of respiration was present in 32 (13.5%), localized wheezing or stridor in 28 (11.8%), and rales or rhonchi in 26 (11%) patients. The duration of symptoms was less than 6 hours in 16 patients (18.5%), 6–24 hours in 34 patients (39%), and more than 24 hours in 37 (42.5%) patients. Overall, the sensitivity and specificity of physical examination in detecting a foreign body were 47.2%

and 74.7%, respectively. PPV and NPV for physical finding were 53.1% and 55.7%, respectively ([Table 2](#)).

Normal radiological findings were found in 81 (64.8%) of 125 patients for whom bronchoscopy was positive. In eight (7.2%) patients, although a positive radiological finding was observed, no foreign body was detected with bronchoscopy. A unilateral hyperlucent lung/obstructive emphysema, the leading radiological finding, was present in 45 (36.0%), mediastinal shift in seven (5.6%), localized atelectasis in seven (5.6%), and pneumonic infiltrations in only six (4.8%) of the FBA confirmed children ([Figures 1A and 1B](#)). Overall, the sensitivity and specificity of radiological findings were 35.2% and 92.7%, respectively. PPV and NPV for the radiological findings were 84.6% and 42.4%, respectively ([Table 3](#)).

Both physical examination and imaging findings were positive in only 24 (19.2%) patients. There was no physical examination or imaging findings in 46 (36.8%) patients.

No major complications or sequelae occurred in any of the patients as a result of the bronchoscopy procedure performed. However, 27 patients had bronchospasm, 25 had mild arterial desaturation, and 12 had bradycardia during the procedure. Through the close cooperative efforts of the surgeon and the anesthetist, these problems were controlled by the withdrawal of the bronchoscope to the level of the carina and by the anesthetist providing better ventilation, with high FiO₂ levels. Owing to the decreased visibility caused by the bleeding of granulation

Table 2 Physical examination findings of children with foreign body aspiration.

Findings	No. of patients	%
Normal	66	52.8
Localized decreased breath sounds	47	37.6
Use of accessory respiratory muscles	32	13.5
Localized wheezing/stridor	28	11.8
Rales/rhonchi	26	11

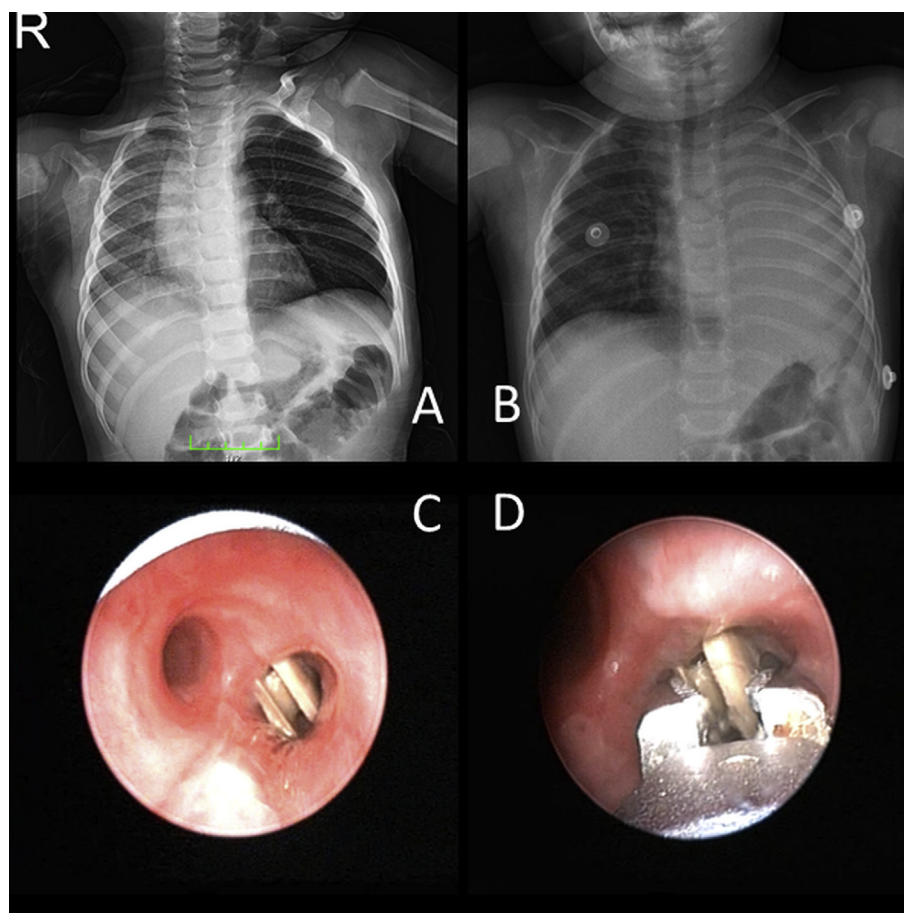


Figure 1 (A) Hyperlucency of left lung due to a check-valve effect of a peanut. (B) Total atelectasis of the left lung. (C) Near-total obstruction of right main bronchus by a plastic cap. (D) Extracting the cap with grasping forceps.

Table 3 Radiological findings in children with foreign body aspiration.

Signs	No. of patients %	
Normal	81	64.8
Hyperlucency/obstructive emphysema	45	36
Mediastinal shift	7	5.6
Localized atelectasis	7	5.6
Pneumonic infiltrations	6	4.8

tissue in two patients, a repeat bronchoscopy had to be performed, twice in one patient and three times in the other patient. In two patients who developed severe respiratory failure, hypoxia, and bradycardia before they were transferred to the operating room to undergo the procedure, death occurred owing to cardiopulmonary arrest, although the foreign bodies were still able to be extracted. The overall mortality rate was therefore 0.8%, although the procedure was not a factor in the patients' death.

4. Discussion

Tracheobronchial FBAs usually occur prior to the age of 3 years, with the most frequently aspirated foreign bodies

being organic food or of a radiolucent nature. Patients with radiolucent FBA may have normal findings during physical examination or on radiographic imaging.

In agreement with literature, most of the FBA-confirmed patients in the study were aged younger than 3 years of age. The percentage of patients who fall within this age group was reported to be about 80–89.5% in literature.^{1–3,9,10} The high incidence of FBA during the early childhood period can be explained by several factors, such as increased mobility of the children, difficulties in parental observation, the child being in the oral stage of life, where objects are identified in an oral manner, lack of molar teeth, and undeveloped coordination between swallowing and respiration. FBA was found to be more common in boys than in girls.^{2,11–13} This can be attributed to boys of this age group being more active and curious than girls of the same age group. In our series, the female/male ratio was 1:1.2.

Most of the foreign bodies in the tracheobronchial tree were found to be foodstuff, including nuts, seeds, fruits, and vegetables, which in literature was shown to vary according to the eating habits of the region and culture and socioeconomic factors. In our series, 78.4% of the foreign bodies were organic in origin, whereas the remaining 21.6% of the foreign bodies were inorganic materials.

A foreign body was found in 71% of the patients with a positive history of an FBA. A choking episode history, or so-called "penetration syndrome," defined as a sudden onset of coughing, acute respiratory distress, wheezing, and/or transient perioral cyanosis, particularly while eating dried fruits or nuts or when laughing or running with an object in the mouth, as witnessed by an adult, is one of the most indicative presentations of FBA among toddlers.^{2,7,8,14,15} However, in this study, 63 (26.7%) patients had no witnessed choking history. According to literature, a positive bronchoscopy has been reported to range between 43% and 79%. Children with FBA are frequently misdiagnosed with recurrent pneumonia, reactive airway disease, croup, bronchial asthma, and intermittent tracheobronchitis. Delayed cases usually occur because of unwitnessed FBA or failure of the legal guardian to notice FBA. Undiagnosed or retained foreign bodies in the tracheobronchial tree causes early and late complications, such as asphyxia, pneumonia, asthma-like symptoms, atelectasis, bronchiectasis, bronchial fistulas, pneumothorax, and subglottic edema. Timely diagnosis and treatment are mandatory to prevent complications. The negative bronchoscopy rate was high (47.1%) in our series, the results of which can be attributed to the fact that a bronchoscopy was performed on any patient with suspected history of FBA in order to make a definitive diagnosis and to reduce the complications related to the misdiagnosed foreign body in the tracheobronchial tree.

A chest X-ray should be taken on all patients with a history of FBA. However, with that said, the diagnostic value of radiological findings remains controversial. Although Vane et al¹⁶ have reported that 97% of X-rays were diagnostic or at least indicative of FBA, a high percentage of children were reported to have completely normal chest X-rays, particularly in literature on radiolucent FBA.¹⁷ Although literature has indicated the sensitivity of the chest X-ray to range between 60% and 90%, the specificity has been shown to be relatively low. In addition, the rate of normal chest X-rays in patients with FBA has been shown to range between 18% and 60%.^{18–20} In our series, chest X-rays showed no imaging findings in 64.8% of the patients confirmed to have FBA. This may be attributed to the relatively short interval of time between the FBA and the imaging, the partial obstruction of the airway, the lack of ability to obtain an expiratory radiograph because of the child's age, and the lack of a radiopaque appearance in a majority of the foreign bodies that are of an organic nature. The most common indirect finding of chest X-rays in suspected foreign bodies has been reported to be localized obstructive emphysema or air trapping (Figures 1A and 1B). Advancement of foreign bodies to the more distal parts of the tracheobronchial system causes air trapping beyond the foreign body, deterioration in the ventilation, and also inflammation and granulation in the mucosa, especially if it is of organic nature, which eventually leads to pneumonia, atelectasis, bronchiectasis, or bronchopleural fistulas. In agreement with the literature, the most common radiological finding in this study was unilateral hyperlucency of the lungs in the FBA-confirmed children. The ball-valve effect of the foreign body in the tracheobronchial tree and hypoventilation result in localized hyperlucent lungs in the chest radiographs. Other radiological findings from our

study included mediastinal shift in seven (5.6%), localized atelectasis in seven (5.6%), and pneumonic infiltrations in only six (4.8%) of the FBA-confirmed children. PPV of radiological finding was determined to be the highest (84.6%) in the clinical and physical findings of this study. Symptoms and clinical findings similar to FBA of the diseases encountered in this age group, such as pneumonia, bronchiolitis, or croup, may have led to the high NPVs for clinical and physical findings.

In our study, the rate of normal physical examinations and chest X-rays in patients with positive bronchoscopy results was 52.8% and 36.8%, respectively. Both the physical examination and imaging findings were normal in 36.8% of the patients. The NPV was found to be highest (96.8%) in cases of a history of a choking event. This may be explained by the fact that an attempt to perform a bronchoscopy was made on every single patient with a suspected history of choking.²¹

Repeated bronchoscopic examinations may be crucial for 1–3% of patients, particularly if the FB is of an organic nature, as it can easily scatter during extraction, or in cases of a longstanding FB, affecting inflammation of granulation tissue, which can easily bleed and lead to image loss during the procedure.²² A repeat bronchoscopy is not considered a complication, as during the waiting period required for the second session, patients receive medication that aids in the healing of the inflamed tracheal tissue and thereby provides the surgeon with another opportunity to perform the procedure. Two of the more recently presented foreign bodies were successfully extracted in the second and third bronchoscopy sessions. Although according to literature, up to 5.3% of patients with FBA require a thoracotomy; in our study, as in the study by Kıyan et al,¹⁸ no patient required a thoracotomy or a tracheotomy.

The mortality rate associated with FBA can often be attributed to the sudden deaths that occur because these individuals failed to receive immediate care. The foods most responsible for aspiration deaths in the USA are hot dogs, candy, nuts, and grapes. Although the mortality rate for tracheobronchial FBA is approximately 1%, the study by Fidkowski et al²³ reported a death rate of 0.42%.²⁴ In children, the most common etiology of aspiration deaths is toys, with balloons accounting for 29% of deaths. Balloon aspirations are reported to be the leading cause of nonfood choking deaths in children.²⁵ Given these risks, it is important that all types of toys be made age-appropriate (Figures 1C and 1D). Localization of the foreign body is another factor related to mortality rates. The narrowest part of the trachea is the cricoid part and fortunately, foreign bodies rarely lodge here; however, should a foreign body get lodged and stuck in this localization, it is imperative that it be promptly removed before it causes hypoxia. Despite successful extraction of a plastic toy balloon as well as a peanut, located just below the vocal cord, which was almost totally obstructing the main airway, death resulting from hypoxic brain damage and cardiopulmonary arrest occurred within 24 hours in two of our patients who were in the intensive care unit.

Our study involved several limitations, including its retrospective design, which might have resulted in complications being underreported; the fact that most of the cases were admitted to the emergency department, where

radiological findings were evaluated by a pediatric surgeon and/or pediatrician rather than by a radiologist, the results of which may have reduced the PPV of radiological findings; and lastly, the unavailability of data on children whose legal guardians did not allow a bronchoscopy to be performed or on long-term complications of bronchoscopies, such as pneumonia.

In conclusion, our study found that tracheobronchial FBAs usually occur prior to the age of 3 years, with the most frequently aspirated foreign bodies being food or substances of a radiolucent nature that cannot easily be detected in chest X-rays. Although no specific symptom, physical examination, or radiological finding is indicative of the presence of a radiolucent FBA, a radiographic finding in the chest radiography is the most valuable predictive tool for deciding to perform a bronchoscopy. Finally, a rigid bronchoscopy is a simple, safe, and appropriate method to be performed on children, not only in terms of making the diagnosis but also in terms of extracting the foreign body.

Conflicts of interest

The authors declare no conflict of interest.

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