Abstract

Inhaled Foreign Bodies In Pediatric Patients: Proven Management Techniques In The Emergency Department

Foreign body inhalation affects thousands of children every year, and it remains a significant cause of morbidity and mortality in children. Inhaled organic or inorganic foreign bodies can become lodged in the posterior nasopharynx, larynx, trachea, or bronchi. Presentation of foreign body inhalation can range from nonspecific respiratory symptoms to respiratory failure associated with a choking episode. In this issue, an in-depth review of the etiology, pathophysiology, diagnosis, and treatment of inhaled foreign bodies is presented. Risk factors for foreign body inhalation and clinical clues to diagnosis, as well as emergent management of inhaled foreign bodies are reviewed. A systematic approach, as described in this issue, will aid in timely and accurate diagnosis and treatment of inhaled foreign bodies, thereby limiting future complications and morbidity.

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Case Presentations

A mother runs past triage screaming, “My daughter is choking!” You run over to assess the child, who is coughing but has good air entry bilaterally, no retractions, and appears generally well in between coughs. The mother reports that her 3-year-old was eating trail mix and started coughing and gasping for air. You debate the need for imaging and wonder how long you should observe this child.

A resident approaches you to present a 6-year-old boy brought in by his father after the child swallowed a small magnetic toy. The father tells you his son coughed and gagged, and now reports that it feels like there is something in his throat. What imaging should you obtain, and what consultants should you call, if any?

You are evaluating a 2-year-old girl who has had 1 week of fever, coughing, and increasing respiratory distress with no known history of foreign body ingestion. You obtain an x-ray that shows significant air trapping in the right lung field, as well as right middle lobe pneumonia. What should you do to stabilize this patient? Is there a role for bronchodilators, racemic epinephrine, and/or steroids? Is any other imaging needed to rule out an inhaled foreign body?

Introduction

Inhaled foreign bodies remain a significant cause of morbidity in children, with reported mortality between 0 and 1.8%. Prior to the advent of advanced endoscopic techniques, mortality rates were reported to be as high as 24%.

Exploring their surroundings with their mouths is a normal part of development that puts children at higher risk of accidental foreign body inhalation than adults. Children aged < 3 years are at greater risk for inhalation of foreign bodies than older children. These young children have immature oropharyngeal coordination, poorly developed or no molar chewing, higher respiratory rates, are more likely to be active and playing while eating, and more likely to experience reflex inhalation while laughing or crying.

According to the United States Centers For Disease Control and Prevention (CDC), an estimated 17,000 children aged < 14 years presented to the emergency department (ED) for choking-related episodes in 2001 (29.9 persons/100,000 population). Approximately 10% of these patients were admitted to the hospital. Choking rates were highest for infants aged < 1 year and decreased with age, with a slight peak in the 5-year-old to 9-year-old age group. Overall, 59.5% of these children were treated for choking on a food substance, 31.4% on a nonfood substance, and 9% on an undetermined substance. The incidence of choking on food versus nonfood substances varied with age. Food substances accounted for 75.7% of choking-related episodes in children aged 5 to 14 years, 58.4% in children aged 1 to 4 years, and 52.1% among infants aged < 1 year. When considering inhaled or aspirated foreign bodies, organic food substances are the most common. Hard candy was the most commonly inhaled food substance (64%), and coins were the most frequently inhaled nonfood substance (18%). Coins accounted for 18.2% of choking-related episodes among children aged 1 to 4 years. However, these data do not distinguish between choking episodes resulting in coins lodged in the esophagus versus the airway.

Foreign body inhalation can present variably, ranging from nonspecific respiratory symptoms to respiratory failure associated with a choking episode. Delayed diagnosis of > 24 hours is common and is associated with increased complications and mortality. In a 2012 meta-analysis of 1063 papers published over a 30-year period, delayed diagnosis of > 24 hours occurred in an estimated 40% of patients, and complications occurred in approximately 15% of these patients. A 2005 retrospective study cited pneumonia, bronchiectasis, and bronchoesophageal fistula as complications of diagnosis delayed > 1 month. Misdiagnosis and parental delay in seeking care were cited as common reasons for delayed diagnosis, although all patients presented with a chief complaint of chronic cough.

Critical Appraisal Of The Literature

A literature search was performed in PubMed using a combination of the search terms pediatrics, child, infant, toddler, inhaled, aspirated, tracheobronchial foreign body, and aspiration pneumonia. Over 150 articles published in the English language were reviewed, and 89 were included in this issue.

Many case series and a significant number of retrospective studies were available, but very few prospective studies were found. There is a lack of uniformity of definitions and management recommendations from center to center, and between specialties. Additionally, there is a paucity of emergency medicine literature, as most articles originate from otolaryngology and surgical literature.

Etiology And Pathophysiology

Most inhaled foreign bodies are reported in children aged < 3 years, with some literature citing more than half of all cases being in this age group. There is a slight predominance commonly reported in boys. Inhaled foreign bodies occur less frequently in infants than in the 1-year-old to 3-year-old age group, and some literature suggests that occurrence in infants aged 0 to 6 months may be associated with inadequate supervision, inappropriate feeding practices, or nonaccidental trauma.

Across the literature, organic objects were reported to be the most commonly aspirated sub-
stances. Although the CDC reports candy as being the most common cause of choking episodes, the majority of the literature indicates nuts and seeds are the most frequently inhaled objects. Overall, organic materials may be associated with a longer length of hospitalization.

Magnets were reported to be the most common cause of inorganic foreign body aspiration, as well as small objects meant for adult use, such as screws and pins. Smooth and round metallic objects, such as magnets, pose an extra challenge for removal as they are difficult to grip with standard forceps. Semi-rigid, rounded organic objects, such as peanuts, have been shown to cause higher severity foreign body-related injuries. Balloons (including rubber glove balloons) have been reported to cause deadly choking episodes. As described in a 2013 case series, blowgun darts have become a cause of accidental foreign body inhalation in older children. While less common, pen caps are a reported inhaled foreign body in school-aged children. In addition, multiple case reports identify headscarf pins as dangerous inhaled foreign bodies in school-aged children of certain cultures.

The 1994 Child Safety Protection Act was enacted in an effort to prevent foreign body aspiration. The act instituted a ban on any toys that could pose choking or aspiration hazards for children aged < 3 years. Any toy with small parts, marbles, or balls measuring < 4.44 cm in size must carry a label that the item contains small parts and is not recommended for young children.

There are 3 typical stages in foreign body aspiration. The first is the impaction phase, characterized by choking, gagging, and coughing paroxysms. This may also be referred to as “penetration syndrome,” characterized by a sudden onset of choking and coughing, with or without vomiting. These symp-

Differential Diagnosis

The main task in creating a differential diagnosis is differentiating an aspirated foreign body from an ingested foreign body, and subsequent differentiation from other conditions that can present similarly. While aspirated foreign bodies typically present with respiratory...

Figure 1. Airway Foreign Body With Atelectasis Of The Left Lung

Figure 2. Screw In The Left Mainstem Bronchus
symptoms, esophageal foreign bodies can also cause respiratory distress from compression on the trachea. Although coughing is generally a good indicator of an aspirated foreign body, it can also indicate an ingested foreign body. Conversely, both aspirated and ingested foreign bodies can be asymptomatic.

When considering alternative diagnoses to an aspirated foreign body, it is useful to organize the possible diagnoses based on the symptoms and the suspected location. (See Tables 1 and 2.) Radiographic imaging may be the best way to differentiate between an airway versus a gastrointestinal foreign body, as ingested foreign bodies (such as coins) are more often radio-opaque, while aspirated foreign bodies are usually radiolucent.

Laryngeal foreign bodies can cause cyanosis and hypoxia with respiratory arrest if the obstruction is complete. Partial laryngeal obstruction can present as dysphonia, hoarseness, croupy cough, and stridor. Croup has been known to mimic a laryngeal foreign body and vice versa. Croup, epiglottitis, and even airway edema from anaphylaxis can present similarly; late symptoms are due to tissue edema and irritation.

In a retrospective study by Huankang et al that included 1007 patients, bronchial foreign bodies can present with dysphonia, dysphagia, dry cough, and biphasic stridor. In these cases, the foreign bodies are usually too large to pass to the bronchus. Also, consider compression from an esophageal foreign body, vascular malformation, airway edema, neoplasm, or abscess.

A bronchial foreign body may be asymptomatic, or it may present with asymmetric or decreased breath sounds, coughing, and wheezing, as well as fever and superimposed pneumonia. These symptoms can also present in the case of pulmonary abscess, pneumonia, asthma, bronchiectasis, congenital lobar emphysema, and cavitary tuberculosis.

Radiographic signs of pneumonia, mass, and abscess may be indistinguishable from complications of a retained aspirated foreign body, so emergency clinicians must maintain a high index of suspicion when deciding whether or not to obtain further imaging or bronchoscopy.

Asthma exacerbation and foreign body inhalation may be clinically and radiographically indistinguishable. In a 2012 retrospective study, patients with a history of asthma who presented with respiratory symptoms as a result of foreign body aspiration were shown to have a significant delay in time between a suspected choking episode and otolaryngology evaluation. This suggests that a conservative approach in patients with asthma is not justified, and reinforces using the clinical history as an important tool in maintaining a high index of suspicion. Diagnosis can be extremely difficult in the case of toddlers presenting with wheezing and upper respiratory infection symptoms in the winter months, when a misdiagnosis of asthma may occur.

In a retrospective study by Huankang et al that included 1007 patients, bronchial foreign bodies

<table>
<thead>
<tr>
<th>Location</th>
<th>Physical Examination Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laryngeal</td>
<td>Hoarseness, stridor, croupy cough</td>
</tr>
<tr>
<td>Tracheal</td>
<td>Biphasic stridor, dysphonia, dysphagia</td>
</tr>
<tr>
<td>Bronchial</td>
<td>Coughing, wheezing, decreased breath sounds</td>
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<table>
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<tr>
<th>Signs/Symptoms</th>
<th>Differential Diagnosis</th>
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<tbody>
<tr>
<td>Coughing</td>
<td>• Esophageal foreign body</td>
</tr>
<tr>
<td></td>
<td>• Pneumonia</td>
</tr>
<tr>
<td></td>
<td>• Asthma</td>
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<td></td>
<td>• Bronchiolitis</td>
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<td></td>
<td>• Croup</td>
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<td>Wheezing</td>
<td>• Asthma</td>
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<td></td>
<td>• Bronchiolitis</td>
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<td></td>
<td>• Vascular malformation</td>
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<tr>
<td>Stridor/hoarseness/dysphonia/dysphagia</td>
<td>• Croup</td>
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<td></td>
<td>• Abscess</td>
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<td></td>
<td>• Vascular malformation</td>
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<td></td>
<td>• Esophageal foreign body</td>
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<td>• Epiglottitis</td>
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<tr>
<td>Asymmetric breath sounds</td>
<td>• Asthma</td>
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<td></td>
<td>• Pneumonia</td>
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<td></td>
<td>• Pulmonary abscess</td>
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<td>• Cavitary tuberculosis</td>
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<td></td>
<td>• Congenital lobar emphysema</td>
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Figure 3. Sunflower Seed Lodged In The Subglottis

were more frequently misdiagnosed than tracheal foreign bodies. Tracheal foreign bodies were more likely to present with dyspnea, while bronchial foreign bodies were more likely to present with decreased breath sounds. In both groups, coughing was the most common presenting symptom. Chest fluoroscopy abnormalities were more often observed in the bronchial foreign body group, while lateral neck x-ray abnormalities were found more in the tracheal foreign body group.

Prehospital Care

Data from case reports indicate that parents and medical professionals should not perform blind finger sweeps in an attempt to dislodge a foreign body, as this can result in further trauma to the airway, or can advance the foreign body farther into the trachea. Once a choking episode is established (the patient is no longer coughing or making sounds), perform 5 back blows followed by 5 chest compressions in a child aged < 12 months or 5 back blows followed by abdominal thrusts in a child aged ≥ 12 months. In a patient in respiratory arrest, a foreign body may be revealed by direct visualization by emergency medical services (EMS) personnel attempting to intubate in the field. In the case of a coughing or wheezing patient, standard supportive care en route to the hospital includes supplemental oxygen, patient positioning for comfort, a trial of bronchodilators (if available), and bag-valve-mask ventilation, if necessary. If complete obstruction is present and bag-valve-mask ventilation is unsuccessful, EMS personnel with the appropriate training may need to perform a surgical airway.

Emergency Department Evaluation

Initial Evaluation

The same principles that apply to prehospital care also apply to the initial ED evaluation. Assessment of airway, breathing, and circulation should be approached according to the Pediatric Advanced Life Support algorithm. Intravenous access and airway stabilization should be initiated, if necessary.

Evaluation Of The Unstable Patient

In an unstable patient with complete airway obstruction, direct visualization using a laryngoscope can be attempted. In these circumstances, Magill forceps should be available at the bedside in case the foreign body is visualized and removal is feasible. If complete airway obstruction is confirmed, the location of the obstruction should be determined, if possible.

Complete Obstruction At The Level Of The Larynx

In a case of complete obstruction at the level of the larynx, if removal is unsuccessful, the next step is a surgical airway. This can include a tracheostomy, cricothyroidotomy, or needle cricothyroidotomy. The latter two are the feasible options for EMS workers and emergency clinicians. The exact age at which surgical cricothyroidotomy is preferred over needle cricothyroidotomy is controversial. Most emergency physicians would not perform surgical cricothyroidotomy and would favor needle cricothyroidotomy in children aged < 8 to 12 years (depending on the size and physical maturity of the child). When performing a needle cricothyroidotomy, the needle is inserted through the cricothyroid membrane into the trachea, connected to an oxygen source using a 3-mL syringe and a 7.5-mm endotracheal tube, and then hooked up to an oxygen source, such as a bag-valve mask or a conventional ventilator machine. Alternatively, percutaneous translaryngeal jet ventilation can be utilized to deliver oxygen to the airways via a needle cricothyroidotomy using a high-pressure gas source. The latter, however, is controversial and is thought to put patients at an increased risk for complications, such as tension pneumothorax and pneumomediastinum, due to the high-pressure air in a closed loop system.

Obstruction Below The Vocal Cords

If the level of obstruction is determined to be below the level of the vocal cords, the patient is in respiratory failure, and there is no improvement with bag-valve-mask ventilation, endotracheal intubation should be performed. If the foreign body is in the trachea, an endotracheal tube can be used to push the object into the right mainstem bronchus in order to ventilate the left lung. Recognition of vital sign instability during resuscitation is crucial, since children are at a higher risk than adults for bradycardia during airway manipulation due to their increased vagal tone. Additionally, children are at higher risk for hypoxia due to their increased oxygen utilization and lower residual capacity.

Evaluation Of The Stable Patient

History

Before ordering any diagnostic studies in a stable patient, obtain a thorough history. Numerous studies point to a history of a choking episode as the most sensitive indicator of foreign body aspiration. In one of the few prospective studies to date, a history of choking was the most common presenting symptom, followed by prolonged cough, dyspnea, and nonresolving pneumonia. However, this study is limited by a small sample size, where only 56 of the 98 patients included were found to have had inhaled foreign bodies. A 2012 retrospective study reported a history of choking as the parameter with the best diagnostic value, citing a sensitivity of 97%, a positive predictive value (PPV) of 89%, and a negative predictive value (NPV) of 80%. Lack of a reported choking episode, however, does not exclude the possibility of
Diagnostic Studies

Radiographic Studies To Assess Signs Of An Aspirated Foreign Body

A 2009 retrospective review of 207 children who underwent rigid bronchoscopy to rule out foreign body aspiration found high sensitivities, but low specificities, for the use of historical clues in the diagnosis of foreign body aspiration. The highest specificities were from radiographic studies. Chest radiography is the preferred initial diagnostic test. Because 80% to 96% of aspirated foreign bodies are radiolucent, inspiratory and forced expiratory films are optimal to assess for radiographic signs of an aspirated foreign body, as opposed to visualizing an actual object. A typical radiographic finding is obstructive emphysema due to partial or complete bronchial obstruction, in which one would see unilateral hyperinflation due to blockage of an air passage during expiration.

Other radiographic signs include air trapping, abnormal heart shadow, mediastinal shift, pneumomediastinum, pneumothorax, and subcutaneous emphysema. (See Figures 4 and 5.) In a 2004 retrospective review, Girardi et al reported 2 previously undocumented radiographic findings: hyperinflation or obstructive emphysema with atelectasis and absence of a witnessed choking episode, lack of physical examination findings, negative radiologic studies, as well as younger age (< 2 years), are all associated with delayed diagnosis (> 72 hours). Conversely, patients with nonspecific symptoms such as coughing and wheezing without a history of a choking episode have been found to be more likely to be diagnosed later. Other historical clues to consider are the at-risk age groups mentioned in the “Etiology And Pathophysiology” section, as well as a history of jumping or playing while eating.

Physical Examination

The next step in evaluation is a physical examination, which should start with a comprehensive head, eye, ear, nose, and throat examination, including thorough examination of the oropharynx and posterior pharynx. Physical examination signs suspicious for an inhaled foreign body include stridor, hoarseness, coughing, wheezing, tachypnea, dyspnea, and asymmetrical breath sounds. Decreased breath sounds and wheezing are the most common physical examination findings.

Figure 4. Subcutaneous Emphysema And Pneumomediastinum

Subcutaneous emphysema (top arrow) and radiolucent air tracking along the pericardial and diaphragmatic curves (bottom arrow) in a 3-year-old with an eraser stuck in the right mainstem bronchus. Reprinted from the American Journal of Otolaryngology, Volume 34, Issue 1. Melissa Hu, Rebecca Green, Anil Gungor. Pneumomediastinum and subcutaneous emphysema from bronchial foreign body aspiration. Pages 85-88. Copyright 2013, with permission from Elsevier.

Figure 5. Right-Sided Hyperexpansion And Mediastinal Shift


Figure 5. Right-Sided Hyperexpansion And Mediastinal Shift
in the same hemithorax, and aeration within an area of atelectasis. Pneumonia and atelectasis are more commonly seen by x-ray in delayed cases. In a 2012 retrospective review of 138 patients who underwent rigid bronchoscopy and were found to have radiolucent foreign bodies, the most common radiographic finding was air trapping, the most common radiologic finding in the majority of studies. Despite the utility of x-ray as a screening methodology, between 20% and 50% of patients with foreign bodies may have negative chest x-rays.

Since infants and young toddlers are unlikely to be able to cooperate with inspiratory and expiratory films, right and left decubitus views have been conventionally used to differentiate air trapping between the lungs, where inadequate deflation on the dependent side suggests obstruction and air trapping. However, a retrospective study by Assefa et al found a sensitivity of 27%, specificity of 67%, PPV of 75%, and NPV of 20%. The authors suggested that, even in the setting of a normal decubitus film, a witnessed choking episode followed by the sudden onset of respiratory symptoms remains the most important indication for bronchoscopy. One limitation to this study is the very small sample size (41 patients over a period of 5 years).

Use Of Fluoroscopy When Inspiratory And Expiratory Films Cannot Be Performed

Fluoroscopy is a viable alternative in children on whom inspiratory and expiratory films cannot be performed. This method allows fluoroscopic visualization of respiratory movements, including decreased movement of the diaphragm on the affected side, and mediastinal shift. However, fluoroscopy is an operator-dependent technique, which weakens its utility for detecting a foreign body in the ED during off hours, especially when computed tomography (CT) is available. In a small prospective study, the sensitivity of fluoroscopy was slightly lower than chest radiography, while the specificity was significantly higher, at 94%.

Computed Tomography To Identify Foreign Bodies

Different studies report high, but variable, sensitivities and specificities for CT, which is reported to be nearly 100% sensitive and 67% to 100% specific for detecting an aspirated foreign body. Thus, CT is more sensitive than x-ray. A 2013 prospective study by Manach et al comparing multidetector CT scan with endoscopy for identifying respiratory foreign bodies found a sensitivity of 94%, specificity of 95%, positive likelihood ratio of 18.1, and negative likelihood ratio of 0.06. Multiple studies support the use of virtual bronchoscopy CT in screening patients for an inhaled foreign body prior to bronchoscopy. These studies demonstrate high sensitivities and specificities, but are somewhat limited by small sample sizes. An advantage of CT is that it is a rapid test that can aid in determining the location of a foreign body, thus decreasing time in the operating room. Additionally, CT can visualize complications of a retained aspirated foreign body, such as atelectasis, bronchiectasis, and pneumothorax, with greater sensitivity and specificity than conventional radiography (See Figure 6.) Disadvantages of CT include radiation exposure, cost, and the need for sedation and its associated dangers in children with inhaled foreign bodies.

Laboratory Markers As Predictive Indicators Of Inhaled Foreign Bodies

Only one study was found that mentioned laboratory markers as predictive indicators, noting an association between increased white blood cell count to > 10,000/dL and an aspirated foreign body. The study was retrospective, with a relatively small sample size of 160, and cited a sensitivity of 39%, specificity of 81%, PPV of 86%, and NPV of 30%. The authors of the study concluded that there is not enough evidence to support the use of laboratory markers in the diagnosis of an inhaled foreign body.

Figure 6. Foreign Body In The Lower Trachea, Shown By Coronal Reconstruction

Clinical Pathway For Management Of Inhaled Foreign Bodies

Asymptomatic child presents to the ED

Witnessed choking episode?

**YES**

Obtain CXR (Class II)

Normal

Observe (Class I)

†Abnormal findings include air trapping, atelectasis, bronchiectasis, pneumomediastinum, subcutaneous emphysema, or pneumothorax.

Abbreviations: AP, anterior-posterior; CT, computed tomography; CXR, chest x-ray; ED, emergency department.

**NO**

Discharge home with close follow-up

Abnormal†

Consult specialist to perform flexible bronchoscopy if clinical suspicion is high (Class III)

Consider CT if clinical suspicion is low or other diagnoses are being considered (Class III)

Observe (Class I)

Symptomatic child presents to the ED

Stable

Obtain history and perform physical examination (Class I)

Unstable/asphyxia

Emergent airway management

Observe, discharge when stable (Class I)

Obtain CXR (consider AP/lateral neck soft-tissue films) (Class II)

Normal

Observe (Class I)

Abnormal†

Consult specialist to perform flexible bronchoscopy if clinical suspicion is high (Class III)

Consider CT if clinical suspicion is low or other diagnoses are being considered (Class III)

Consult specialist to perform rigid bronchoscopy for removal (Class III)

Foreign body visualized?

**YES**

Rigid bronchoscopy for removal (Class III)

**NO**

Observe (inpatient or outpatient, at physician’s discretion) (Class I)

Consult specialist to perform flexibe bronchoscopy if clinical suspicion is high (Class III)

Consider CT if clinical suspicion is low or other diagnoses are being considered (Class III)

Observe (Class I)

Consult specialist to perform bronchoscopy if clinical suspicion is high (Class III)

Consider CT if clinical suspicion is low or other diagnoses are being considered (Class III)

Observe (inpatient or outpatient, at physician’s discretion) (Class I)

Class Of Evidence Definitions

Each action in the clinical pathways section of Pediatric Emergency Medicine Practice receives a score based on the following definitions.

**Class I**
- Always acceptable, safe
- Definitely useful
- Proven in both efficacy and effectiveness

**Level of Evidence:**
- One or more large prospective studies are present (with rare exceptions)
- High-quality meta-analyses
- Study results consistently positive and compelling

**Class II**
- Safe, acceptable
- Probably useful
- Generally higher levels of evidence
- Nonrandomized or retrospective studies: historic, cohort, or case control studies
- Less robust randomized controlled trials
- Results consistently positive

**Class III**
- May be acceptable
- Possibly useful
- Considered optional or alternative treatments
- Generally lower or intermediate levels of evidence
- Case series, animal studies, consensus panels
- Occasionally positive results

**Indeterminate**
- Continuing area of research
- No recommendations until further research

**Level of Evidence:**
- Evidence not available
- Higher studies in progress
- Results inconsistent, contradictory
- Results not compelling

This clinical pathway is intended to supplement, rather than substitute for, professional judgment and may be changed depending upon a patient’s individual needs. Failure to comply with this pathway does not represent a breach of the standard of care.

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Specialty Consultation

Consultation with otolaryngology, pulmonary, or surgical specialists should be considered, depending on institutional policy and the location of the retained foreign body. In most circumstances, if the foreign body is above the level of the vocal cords, otolaryngology should be consulted to perform endoscopy. In cases of bronchial foreign bodies where rigid bronchoscopy is required, otolaryngology or pulmonology should be consulted, depending on institutional protocol. Rigid bronchoscopy is generally thought to be safe and effective when performed under general anesthesia in the operating room, with a first-pass success rate of up to 99%. Otolaryngology literature suggests that flexible bronchoscopy should be used initially in cases of low suspicion of an aspirated foreign body (eg, the absence of unilateral breath sounds, atelectasis, or obstructive emphysema on a chest x-ray). If negative, rigid bronchoscopy and its associated cost and complications (including bradycardia, hypoxia, pneumothorax, perforation, bleeding, and even bronchial rupture) can be avoided. If a foreign body is found on flexible bronchoscopy, then rigid bronchoscopy must be performed for removal. In some institutions, flexible bronchoscopy can be performed at the bedside by a senior emergency physician, although it is largely within the scope of surgical subspecialty practice.

Treatment

While spontaneous expulsion prior to or during intervention has been reported, the definitive treatment of an aspirated foreign body is removal by bronchoscopy, either by an otolaryngologist or another subspecialist. Although rigid bronchoscopy is the standard treatment, there is a recent move toward flexible bronchoscopy to avoid the complications of rigid bronchoscopy. Limitations to flexible bronchoscopy include foreign bodies that are too large to pass through the bronchoscope and sharp objects that cannot be gripped. Both methods generally require sedation and manual or mechanical ventilation (with their inherent complications), although a randomized controlled trial suggested that the use of dexmedetomidine may allow for spontaneous ventilation during bronchoscopy, due to respiratory sparing properties. In cases of delayed diagnosis, rigid bronchoscopy may be negative (eg, a case where an organic foreign body was resorbed or dissolved). Cohen et al recommended observation and close follow-up in patients with a history suggestive of foreign body inhalation but no symptoms or radiographic findings. Likewise, Mani et al performed a retrospective study that demonstrated no increased morbidity from delaying bronchoscopy and observing patients with a history of possible foreign body aspiration but no signs or symptoms. Definitive treatment is endoscopic removal but, rarely, thoracotomy and tracheotomy are necessary if endoscopic removal fails and the patient is unstable. If endoscopic removal is not successful and the patient is stable, but rigid bronchoscopy is not available, the patient should be transferred to a center with bronchoscopy capabilities. Complications of treatment by endoscopic removal include hypoxia, tissue trauma, and perforation. Surgical intervention is an important option in the cases of sharp, inorganic foreign bodies, as they may be more difficult to extract bronchoscopically.

Although not in the scope of an emergency clinician’s practice, case reports have described foreign body removal using catheterization, in a cardiac catheterization laboratory under fluoroscopy, if bronchoscopic removal fails. Thatte et al describe 2 such cases, 1 of which was successful. The other case was unsuccessful and resulted in surgical lobectomy. In another case report by Varshney et al, a urology basket was used in conjunction with flexible bronchoscopy to successfully retrieve bronchial foreign bodies in 2 patients. Additionally, balloon catheters have been used in bronchial foreign body removal. Adjuncts such as epinephrine, beta agonists, and steroids for airway edema are referred to anecdotally in the surgical literature. Another case report described a patient coughing up an aspirated peanut after receiving nebulized salbutamol.

Special Populations

Older children with developmental delay seem to be at a higher risk of aspiration of foreign bodies for the same reasons as younger children: a persistence of the need to explore the environment with their mouths, as well as oropharyngeal coordination issues and communication barriers. Children with neuromuscular disorders may also have swallowing coordination issues, weakness of the oropharyngeal muscles, and a depressed gag reflex. A case report describing a patient who was misdiagnosed with progressively worsening sleep apnea over a period of 5 years and was eventually found by CT to have a retained aspirated foreign body suggests that children with Prader-Willi syndrome may also be at higher risk.

Controversies And Cutting Edge

While no published studies were found on the use of ultrasound to identify aspirated foreign bodies, the use of ultrasound in the ED is becoming ubiquitous, and there is a potential application for ultrasound in the detection of foreign bodies. The use of ultrasound to identify endotracheal tube placement is well established in animal and human models.
Techniques to identify endotracheal tube placement include direct transtracheal visualization, lung sliding, and diaphragm visualization to assess symmetric lung movement with breaths. Theoretically, all of these techniques are applicable to tracheal or even bronchial foreign bodies to assess air trapping, hyperinflation, and decreased diaphragmatic movement on the side of obstruction.

**Time- And Cost-Effective Strategies**

- Chest radiography is the first line of investigation in the management of a patient with a suspected inhaled foreign body. Normal chest radiography does not exclude the diagnosis of an inhaled foreign body, and additional investigations are sometimes necessary.
- CT has high sensitivity in detecting inhaled foreign bodies, and it can be used in diagnosing inhaled foreign bodies in selected low-suspicion cases. With multidetector CT, the speed of performing a CT scan has increased dramatically, and there are fewer requirements for sedation. In addition, multidetector CT imaging can obviate the need for rigid bronchoscopy and the risks associated with the procedure. However, the associated adverse risks of ionizing radiation should be kept in mind when considering CT.
- Flexible bronchoscopy is routinely used to evaluate a child with recurrent pneumonia or chronic cough, but recently, it has been shown to be effective and safer than rigid bronchoscopy for excluding the presence of a foreign body in patients for whom there is a low suspicion of foreign body inhalation. The use of flexible bronchoscopy can reduce the necessity of performing rigid bronchoscopy. The decision of whether or not to use flexible or rigid bronchoscopy is best made in conjunction with all subspecialists involved, which may include emergency medicine clinicians, otolaryngologists, surgeons, or pulmonologists.
- The American Academy of Pediatrics recommends that anticipatory guidance should be provided to parents when their child is 6 months of age. At this age, children begin to develop the fine motor skills needed to pick up small objects. It is important to advise parents not to offer small food items, such as peanuts, until the child is old enough to chew properly. It is also important to advise parents to discourage their child from eating while running, laughing, or playing, and to encourage their child to sit upright while eating.

**Disposition**

For a patient with a foreign body definitively identified on imaging or a high enough suspicion to proceed with bronchoscopy (eg, witnessed aspiration or sudden onset of severe respiratory distress), disposition from an inpatient service should be determined by the subspecialty service. No patient with an airway foreign body should be discharged from the ED. In patients in whom there is some suspicion of a foreign body but no definitive physical examination or imaging findings, observation in the ED or inpatient observation unit for 12 to 24 hours is appropriate to watch for onset of respiratory distress or changes in radiologic images (such as new-onset air trapping or opacification). Alternatively, depending on the emergency clinician’s index of suspicion, the patient can be discharged home to be observed by the parents. Discharge instructions for patients in whom a foreign body is suspected, but not diagnosed, should always include concise instructions to seek medical care if the child develops fast breathing, fever, persistent cough, chest pain, persistent vomiting, or any other concerns.

**Summary**

Aspirated foreign bodies remain a significant cause of morbidity and mortality in children. The highest rates are in children aged < 3 years. Food accounts for most inhalations, and coins are associated with 18% of choking-related episodes. Foreign body inhalation presents variably, thus the history and physical examination should guide the workup. A high index of suspicion should be maintained in at-risk groups, while being mindful of minimizing unnecessary procedures and radiation. Although chest radiography can be diagnostic for foreign body inhalations, most inhaled objects are radiolucent, and, thus, there are limitations to this technique. CT imaging, fluoroscopy, and bronchoscopy can be performed in cases with a high index of suspicion and when basic chest radiography is inconclusive.

Once a foreign body is suspected or confirmed, clinical management includes recognition, acute emergency interventions, and supportive care. In most centers, rigid bronchoscopy is used to remove a foreign body, while flexible bronchoscopy can be used for evaluation in cases of low suspicion of an inhaled foreign body. Disposition after bronchoscopy is at the discretion of the subspeciality services. Disposition from the ED should include discharge instructions advising parents to seek medical care if any signs or symptoms suspicious for a foreign body arise.

There is significant cost associated with foreign body inhalation, justifying the need for increased prevention efforts. Current educational prevention efforts in the United States are led by the National Safety Council, the CDC, and the American Academy of Pediatrics.
1. “The x-ray appears normal, so there can’t be a foreign body.”
Normal x-ray findings do not exclude radiolucent foreign body aspiration. Additionally, radiographic signs may be delayed > 24 hours. Most aspirated foreign bodies are organic, which includes food products, paper, and other mostly radiolucent objects. Radio-opaque objects include glass and metal; however, many plastic objects will not be radio-opaque.

2. “No one saw him choke or cough, so a foreign body is not on my differential.”
While a witnessed choking episode is helpful in suspecting the diagnosis of foreign body inhalation, it is not present in the majority of cases, and, therefore, its absence does not exclude an inhaled foreign body.

3. “Some kids are just prone to pneumonia; it doesn’t mean it’s a foreign body.”
Recurrent or nonresolving unilateral pneumonia should raise the emergency clinician’s suspicion for a retained inhaled foreign body, and workup should be done before the assumption is made that the child is simply prone to pneumonia. Infection usually occurs distal to the site of obstruction, as a late complication.

4. “I thought patting the choking toddler, who was coughing and gasping, on the back would help to dislodge the foreign body he was choking on, but instead, his status worsened and he stopped breathing.”
In infants aged < 12 months, chest compressions or back blows are the preferred method to dislodge a foreign body. In older children, abdominal thrusts are preferred. However, these methods are indicated in cases of complete obstruction and should not be attempted if a patient is coughing or able to speak (partially obstructed), as these methods can cause complete obstruction.

5. “I saw a patient bite off a piece of a ‘glove balloon’ and start coughing right in front of me. What is the harm of trying to get it out with my finger while it still may be in his posterior pharynx?”
By the time a patient is coughing, the foreign body is probably at least at the level of the larynx. Blind finger sweeps can not only further dislodge any material that is left in the posterior pharynx, but can cause significant trauma to the delicate tissues. In this case, direct visualization with direct laryngoscopy and the use of Magill forceps for removal at the bedside may be indicated.

6. “He has no symptoms, so let’s just discharge him.”
Foreign body inhalation may be asymptomatic for hours to weeks after the event. History and index of suspicion, in addition to the presence of symptoms, should guide the decision to image and/or observe the patient.

7. “He is wheezing and the x-ray shows atelectasis. He isn’t really improving in the ED, but it’s probably just asthma. Let’s admit him for steroids, bronchodilator therapy, and observation.”
While there may be a role for bronchodilator therapy in the event of an inhaled foreign body, any patient with abnormal x-ray findings who fails to improve with bronchodilator therapy should be assessed for a possible inhaled foreign body. Inspiratory/expiratory films, fluoroscopy or CT, as well as a thorough history and physical examination, may help elucidate the diagnosis.

8. “This child will never cooperate with inspiratory and expiratory films; let’s just do a CT.”
An x-ray may show signs of air trapping or a radio-opaque foreign body without inspiratory/expiratory films. Additionally, although the sensitivity of decubitus films is debatable, they may show air trapping that would be an indication for bronchoscopy, thus avoiding a CT. Disadvantages of CT are the cost and time of testing, the possible need for sedation with its inherent risks, and the risks of radiation.

9. “There is no way my child could have inhaled a toy. It just wouldn’t fit!”
According to the 1994 Child Safety Protection Act, any toy with small parts (defined as < 4.44 cm) is considered a choking hazard to small children.

10. “The child has stridor, but the chest x-ray is negative, so there is no foreign body, right?”
Stridor is indicative of a tracheal or laryngeal foreign body, both of which may not be seen on chest films. Anterior-posterior and lateral neck films should be obtained in the case of stridor. The index of suspicion should drive the decision to order a bronchoscopy for a foreign body rather than image alone.
Case Conclusions

You decided to x-ray the 3-year-old girl and saw normal posterior-anterior and lateral x-rays with no visualized foreign body. However, due to her persistent cough, you observed the child for 24 hours to assess for worsening respiratory distress. Her cough resolved, and there was no need for a repeat x-ray. You counseled the mother on “danger foods” and the risks for choking, such as playing or jumping while eating.

Because magnet ingestion or inhalation is a true emergency due to the risk for pressure necrosis, you obtained anterior-posterior and lateral x-rays to confirm the location of the magnet in the trachea of the 6-year-old boy. You called for an emergent otolaryngology consult for removal using rigid bronchoscopy.

The x-ray findings of air trapping in the 2-year-old girl raised your suspicion for an inhaled foreign body, even though there was no radio-opaque foreign body seen on x-ray. You stabilized the patient with supplemental oxygen and intravenous antibiotics for her pneumonia and respiratory distress. You then decided to obtain a CT, on which a foreign body was seen with surrounding edema and pneumonia in the right mainstem bronchus. The patient was sent for bronchoscopy, and a peanut was removed.

References

Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study, such as the type of study and the number of patients in the study will be included in bold type following the references, where available. The most informative references cited in this paper, as determined by the author, will be noted by an asterisk (*) next to the number of the reference.


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5. Which of the following is the most sensitive indicator of foreign body aspiration?
   a. Abnormal x-ray
   b. Witnessed choking episode
   c. Hypoxia
   d. Tachypnea

6. What is the best initial choice of imaging in the case of suspected foreign body inhalation?
   a. CT
   b. Fluoroscopy
   c. Decubitus x-rays
   d. Inspiratory and expiratory x-rays

7. Which of the following are radiographic findings of foreign body aspiration?
   a. Mediastinal shift
   b. Subcutaneous emphysema
   c. Pneumomediastinum
   d. All of the above

8. Which of the following is the greatest limitation to performing inspiratory and expiratory films?
   a. They are operator dependent
   b. They are not specific
   c. They require patient cooperation
   d. They take too long

9. You are evaluating a developmentally delayed 7-year-old for recurrent right middle lobe pneumonia. The patient is stable, but you suspect a foreign body. What is the next best study in evaluation of this patient?
   a. Flexible bronchoscopy
   b. Rigid bronchoscopy
   c. CT
   d. CBC with differential

10. You performed an x-ray on a patient with a witnessed choking episode to look for a foreign body. The x-ray is normal, and the patient is asymptomatic. How will you disposition this patient?
    a. Discharge home to be observed by the parents, follow-up as needed
    b. Observe in the ED for 12 to 24 hours and then discharge home, follow-up as needed
    c. Admit to the hospital for respiratory monitoring
    d. a or b
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**Goals:** Upon completion of this activity, you should be able to: (1) demonstrate medical decision-making based on the strongest clinical evidence; (2) cost-effectively diagnose and treat the most critical ED presentations; and (3) describe the most common medicolegal pitfalls for each topic covered.

**Objectives:** Upon completion of this article, you should be able to: (1) Discuss the utility of various radiologic and imaging approaches to foreign body inhalation; (2) describe the variations in ED management of foreign bodies located in the upper versus lower airway; (3) list the characteristics of patients and objects that are at higher risk for foreign body inhalation; and (4) identify clinical clues of a chronic and acute related aspirated foreign body.

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