

METHODS IN INSTRUMENTATION FOR REMOVAL OF AIRWAY FOREIGN BODIES

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The principles of diagnosis and management of airway foreign body aspiration has not changed since the days of Chevalier Jackson. History and physical examination continue to be the most important aspects in diagnosis and management. The development of optical endoscopic equipment and advances in anesthesia has made the treatment safer. This report will discuss the initial evaluation and methods in preparation and surgical treatment of foreign body removal.

Airway foreign bodies continue to challenge physicians, both in their diagnosis and management. More than 3,000 deaths per year are associated with asphyxiation,¹ with most people dying before hospital intervention. Because foreign body aspiration is often unwitnessed and can mimic other disease processes, a high index of suspicion is needed for timely treatment.

The incidence of foreign body aspiration has been consistent over time, with the majority occurring under the age of 15 years. The highest incidence occurs between 1 and 3 years of age.^{2,3} Toddlers are most susceptible to foreign body aspiration because of (1) Lack of molars to properly grind food, (2) immaturity of swallowing and glottic function, (3) age-related interest in exploring the environment by placing objects in their mouth, and (4) running or playing at the time of aspiration.⁴ The most common airway foreign bodies in the United States are vegetative matter, specifically peanuts. Plastic toys comprise 5% to 15% of foreign body aspirations and are many times inert, resulting in a delay in diagnosis and treatment.

Between 80% and 90% of airway foreign bodies become lodged in the bronchi,⁵ with a predilection for the right main bronchus in adults. In children, there tends to be an equal distribution of right and left main bronchi.⁶ Larger objects tend to become lodged in the larynx and trachea.

In general, there are 3 phases of foreign body aspiration.⁷ The initial phase represents choking, gasping, coughing, or airway obstruction. The second phase, or asymptomatic stage, relates to the relaxation of the initial

reflexes and often produces no symptoms. This stage can last from hours to days. The third phase, or complications phase, is the time when the foreign body has produced subsequent events, such as pneumonia, abscess formation, or atelectasis.

Clinical presentation is dependent on the location of the foreign body in the airway. Large objects lodged in the larynx and trachea may produce complete airway obstruction, either from the object's dimensions or the resulting edema. Laryngeal foreign bodies typically present as hoarseness or airway obstruction. Tracheal foreign bodies present with airway obstruction but no hoarseness. Tracheal foreign bodies can mimic asthmatic wheezing. Bronchial foreign bodies classically present with the triad of cough, wheezing and decreased breath sounds, with one study showing 65% of patients present with the triad,⁶ and 95% with at least one finding.⁸

DIAGNOSIS

The majority of children who arrive at the hospital after a foreign body aspiration have passed the acute stage and may be asymptomatic. A careful and complete history and a directed physical examination are critical, and they are the most important aspects in helping to decide whether further treatment is needed. Children with a witnessed event or outward physical signs and symptoms of a foreign body aspiration will undergo endoscopic treatment, but some children do not have a conclusive history and physical examination, which makes the decision-making process difficult at times. Radiographic evaluation is adjunct to the history and physical examination and should be performed on all children as a baseline examination. At times, it can be diagnostic, with a radio opaque object visualized (Fig 1). Anteroposterior and lateral high kilovolt neck films are useful in the diagnosis of laryngotracheal foreign bodies. Esclamado and Richardson reported that 92% of patients with tracheal foreign bodies showed an abnormal neck radiograph, and 50% of them had normal chest radiographs.⁵ In bronchial foreign body aspiration, chest radiographs are an adjunct to the diagnosis and

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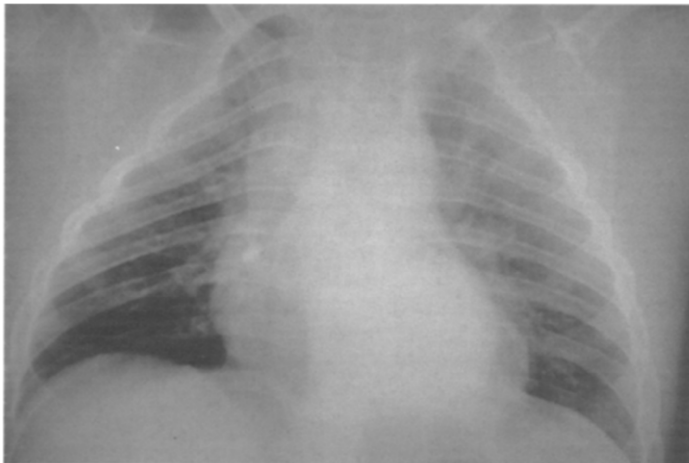


FIGURE 1. Foreign body (tooth) in right main bronchus.

should not alter the decision for endoscopic intervention. Bronchial foreign bodies may be present despite normal chest radiographs, with Silva reporting the sensitivity and specificity rate of identifying an airway foreign body of 73% and 45%, respectively.⁷ Inspiratory and expiratory chest radiographs can aid in the diagnosis, with hyperinflation on expiratory films and atelectasis on inspiratory films. Lateral decubitus films can be helpful in young, uncooperative children, with the dependent lung remaining inflated when it should collapse. Fluoroscopy has not shown a significant benefit in the diagnosis of foreign body aspiration, with an up to 50% false negative rate.⁸ Biplane fluoroscopy is used in the extraction of radio opaque foreign bodies in the lung periphery.

The diagnosis of an airway foreign body can be elusive based on the fact that a child may have no history of a witnessed aspiration, no abnormality on physical examination, and no abnormality on radiographic studies. The only definitive means to rule out a foreign body is laryngoscopy and bronchoscopy. When a physician suspects that an airway foreign body exists, a safe and timely endoscopy needs to be performed.

MANAGEMENT

The removal of an airway foreign body can be life-saving as well as life-threatening. It is preferable (when the situation and time permits) to perform airway foreign body extraction in a setting with pediatric services available. This includes a pediatric intensive care unit, should a complication arise from the procedure or ventilation be necessary postoperatively. The procedure should be performed by a physician with pediatric airway experience and familiarity with pediatric endoscopic equipment. In addition, the anesthesiologist should have pediatric experience and be comfortable in managing a difficult pediatric airway. If the child is stable and less than ideal conditions exist, it is appropriate to transfer the child to a facility that is better suited for the procedure and care of the infant or child. Unless the child is in extremis or impending demise, the procedure should take place after an appropriate amount of time for nothing by mouth occurs.

Parents need to be informed as to the risks of the procedure, including airway edema, pneumonia, pneumomediastinum, inability to remove the foreign object, airway obstruction, and death.

EQUIPMENT

In general, performing a safe and controlled foreign body removal requires orchestration of the endoscopist, anesthesiologist, and operating room personnel. Communication with the anesthesiologist about the anesthetic and endoscopic plan should occur before entering the room with the child. Operating room personnel should be familiar with the procedure and the equipment used. Age-appropriate endoscopic equipment reduces airway trauma and edema, and should be selected before the child enters the room (Table 1). The preferred bronchoscopes are the Doesel-Huzly bronchoscopes with rod-lens telescopes (Karl Storz, Culver City, CA). Two sets of laryngoscopes and bronchoscopes should be available in case one set fails. Laryngoscopes are used for removal of a laryngeal foreign body when present and to facilitate passing of the bronchoscope. Various foreign body forceps, with both active and passive action, should be available, along with newer optical forceps. The optical forceps are preferred because of magnification of the object, allowing easier visualization; when using a camera attached to the telescope of the optical forceps, all personnel in the operating room can visualize the procedure. Having a duplicate object present for comparison helps in the selection of foreign body forceps. Appropriate-sized flexible and rigid suction equipment must be in working order before initiating the procedure.

ANESTHESIA

Foreign body removal is performed under general anesthesia unless the patient is in extremis. Nothing by mouth for an appropriate amount of time should occur, typically 6 to 8 hours for solids and 2 to 4 hours for clear liquids. Patients are given inhalational anesthetics by mask anesthesia in the supine position and are spontaneous ventilating throughout the procedure for control of the airway. Topical lidocaine of 1% to 2% is given for laryngeal reflex inhibition and to reduce the incidence of laryngospasm. Constant communication between the endoscopist and anesthesiologist is critical throughout the procedure to ensure safe and successful foreign body removal.

LARYNGEAL FOREIGN BODY REMOVAL

Patients are anesthetized by mask induction and are maintained under anesthesia by an insufflation catheter placed through the nares, with the catheter tip located in the hypopharynx. After the patient is adequately oxygenated, the laryngoscope is placed in the vallecula for laryngeal exposure. The foreign body is visualized and removed

TABLE 1. Guidelines in Selection of Bronchoscopes and Laryngoscopes By Age

Age (Range)	Bronchoscope Size (Outer Diameter in mm)	Laryngoscope Size
Premature infant	2.5 (3.7)	8
Term infant (up to 3 months)	3 (4.8)	8
6 months (3-18 months)	3.5 (5.7)	9
18 months (1-3 years)	3.7 (6.3)	9.5-11
3 years (2-6 years)	4 (6.7)	9.5-12
7 years (5-10 years)	5 (7.8)	12
10 years +	6 (8.2)	16

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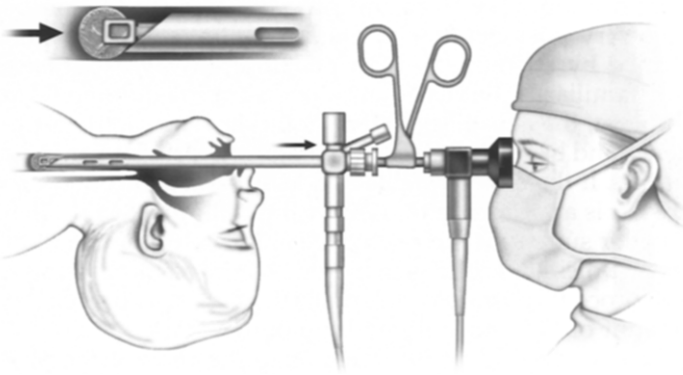


FIGURE 2. Illustration of bronchoscope inserted into child's airway (endoscopist holding bronchoscope).

with foreign body forceps. The laryngoscope is reinserted to re-examine the larynx for additional foreign bodies. Bronchoscopic evaluation proceeds for evaluation of the trachea and bronchi for further foreign bodies. Occasionally, a laryngeal foreign body may be firmly lodged or severely obstructing the larynx. In these situations, it may be necessary to secure the airway by performing a temporary awake tracheotomy before removing the foreign body.

TRACHEOBRONCHIAL FOREIGN BODY REMOVAL

Anesthesia through mask induction is performed and maintained by mask, with the patient spontaneously breathing. The laryngoscope is placed in the vallecula for laryngeal exposure, and an age-appropriate sized bronchoscope is inserted through the larynx into the trachea. The patient is ventilated and anesthetized through the bronchoscope while the bronchoscope is in the airway (Fig 2). In the case of a tracheal foreign body, the object is visualized within the trachea and gentle suction is performed around the object for removal of surrounding secretions for better visualization. In the case of bronchial foreign bodies, the unaffected side is examined first. The foreign body is visualized within the affected bronchus, and secretions are gently suctioned around the object. For tracheal or bronchial foreign bodies, the bronchoscope is placed directly above the object. One hundred percent oxygen is administered before any attempt at foreign body removal. An appropriately chosen foreign body forceps is inserted through the bronchoscope, and the foreign body is grasped. While keeping the foreign body engaged, the bronchoscope is moved to the foreign body, and the bronchoscope, foreign body, and foreign body forceps are removed as a unit from the airway (Fig 3). The bronchoscope is immediately returned to the airway for continued ventilation and reassessment for other foreign bodies. Occasionally, small foreign bodies may be removed directly through the bronchoscope.

SPECIAL SITUATIONS: TRACHEOBRONCHIAL FOREIGN BODIES

During attempted extraction of bronchial foreign bodies, it is possible to lose control of the object or food matter and completely occlude the laryngeal or tracheal airway, creating a potential airway emergency. In this situation, the foreign body must be removed quickly or pushed distally into one of the main stem bronchi so that ventilation can

resume. Once the patient is reoxygenated, another attempt at removal is undertaken.

Another problematic situation can arise when a foreign object (ie, small pieces of peanut) is located in one of the distal bronchial segments and cannot be easily reached with the forceps. A useful adjunct in this situation is to place a Fogarty (Baxter, Irvine, CA) endovascular catheter (4 or 5 French) through the suction port. The balloon of the distal end of the catheter is placed just distal to the foreign body. Saline (between 0.3 mL and 2 mL, depending on the depth of the catheter) is then slowly and carefully injected into the balloon, and the catheter and foreign body are pulled gently into the lumen of the bronchoscope and extracted. The endoscopist must practice this technique before its use in the distal airway.

There are situations where attempts at foreign body removal have failed and alternate techniques are needed. The object may become embedded in the surrounding mucosa because of edema formation by the object itself, or after multiple attempts at removal have occurred. Waiting an additional 48 to 72 hours to allow for the edema to subside before a repeat attempt is prudent. Thoracotomy or bronchotomy may be necessary in cases in which the foreign body cannot safely be removed endoscopically. The object may be too large to remove through the larynx; it can be broken into smaller pieces and removed piecemeal. A tracheotomy can be performed, with the object removed through the tracheostoma, while maintaining the airway at all times.

SHARP OBJECTS

Endoscopic removal of sharp objects is extremely challenging. Typically, the pointed end engages into the mucosa, allowing the object to tumble with the pointed end trailing.¹⁰ These objects also tend to be bendable or breakable. The bronchoscope is placed above the object, with a foreign body forceps used to disengage the object from the mucosa by moving the object distally. The object, forceps, and bronchoscope are removed as a unit. Safety pin removal presents a uniquely challenging problem, because most that are aspirated are open. The incidence of safety pin aspiration has decreased with the advent of disposable diapers. The pointed end is sheathed into the bronchoscope, and the keeper is locked outside the bronchoscope. Severely impacted pointed objects may benefit from a thoracotomy approach.

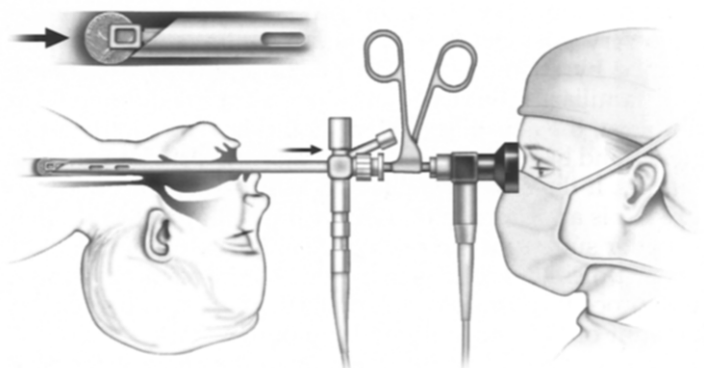


FIGURE 3. Illustration of bronchoscope, optical forceps with endoscopist removing as a unit.

POSTOPERATIVE CARE

Children are observed for at least 4 hours after the procedure. Antibiotics are not routinely used unless purulence is noted at the time of bronchoscopy. Racemic epinephrine or steroids are not necessary if age-appropriate endoscopes are used. Follow-up radiographic studies are not ordered unless symptoms persist. Pediatric intensive care may be needed in certain situations.

COMPLICATIONS

Most complications are the result of delay in diagnosis.¹¹ Pneumonia and atelectasis are the most common complications after bronchial foreign body removal. Bleeding may occur either from granulation tissue, or rarely from erosion through a surrounding vessel. Pneumomediastinum and pneumothorax can occur after an airway tear. Granulation tissue and stenosis at the site of lodgment can occur, particularly with the oils of nuts.¹²

CONTROVERSIES IN MANAGEMENT

Nonendoscopic means of management of airway foreign bodies have been suggested in the past. The use of chest physiotherapy and bronchodilators is not recommended.¹³ Flexible bronchoscopic foreign body removal has been suggested in the adult literature, but is not advocated in children because of poor airway control and difficulty with extraction of airway foreign bodies. The use of a rigid, ventilating bronchoscope under general anesthesia continues to be the safest method of foreign body extraction.

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