Update on Choking Emergencies: Foreign Bodies of the Respiratory Tract

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Objective: This article review the current principles in the management of children and infants with foreign bodies in their respiratory tracts.
ACGME Competencies: Patient Care, Medical Knowledge

Abstract:

Aspirated foreign bodies, whether in the upper airway or the lower airway, continue to present challenges to physicians who care for children in the acute setting. Appropriate maneuvers to relieve foreign body upper airway obstruction are age dependent. With children and infants who have foreign bodies in their lower airway, a high index of suspicion is required in order to make a timely diagnosis. Often the initial choking events are not witnessed, and the delayed symptoms may mimic other common conditions. Proper anticipatory guidance and education is the optimal way of reducing the tragic outcomes of choking events. This article reviews the current principles in the management of children and infants with foreign bodies in their respiratory tracts.

Introduction:

Upper airway foreign body obstruction and aspirated foreign bodies are a major cause of childhood mortality and morbidity and continue to present challenges to physicians who care for children. These events are not new occurrences. In 1633, the London physician, Stephen Bradwell, wrote, "Of things that endanger stopping of the breath in swallowing, some are sharp and some blunt… I have heard of a child in Woodstreet strangled with a grape."[1] Then, as now, bystanders often perform prompt, effective life-saving maneuvers to children with foreign bodies in their upper airway. These life-saving maneuvers are age dependent and are usually performed in the field prior to arrival at a health care facility. Additionally, the diagnosis of a foreign body in the lower airway has added difficulty because these choking events are unwitnessed and the delayed symptoms may mimic other common conditions such as asthma, recurrent pneumonia or upper respiratory tract infections. This article reviews the clinical presentation, diagnostic work–up and appropriate management of children and infants with foreign bodies in their respiratory tract.

Background:

Hundreds of pediatric choking deaths occur every year in the United States.[2-11] Between 1999 and 2013, 2103 children under 15 years of age died due to foreign body airway obstruction.[12] Studies show that ninety percent of deaths occur in infants and children less than 5 years of age and 65% in those less than 2 years of age. Approximately 80% of pediatric foreign body aspirations occur in children less than three years of age, and those young patients are also at greatest risk of death.[4,13] These deaths are usually attributable to aspiration of foods, toys or other small objects. Organic debris is commonly retrieved from the upper airway by appropriate first aid maneuvers in children who have acute upper airway obstruction and by bronchoscopy in the lower airway. Hot dogs, candy, grapes and peanuts are the most common foods recovered.[5-11, 14-16] The shape and smoothness of these foods is thought to enable them to pass easily into the upper airway.

The description of the "café coronary" in 1963, heightened the awareness of the causes, prevention and emergency treatment of food-related choking events in adults.[17] This paper reported nine cases of sudden death in adult restaurant patrons that occurred when a piece of meat acutely obstructed the victim's upper airway. The authors suggested an association in adults between choking on food, excessive alcohol intake and poorly fitted dentures. A 1984 report focused increased attention on food-related choking episodes in children.[16] Analyzing national data on all identified food-related asphyxiation events in infants and children up to 9 years of age from 1979 to 1981, one such death occurred every five days. More than 90% took place in infants and children younger than 5 years of age and 65% in infants younger than 2 years of age. Round or cylindrical foods were the most common culprits in these events. Foods are the most common cause of choking events in toddlers. The natural curiosity of the toddler, the ubiquitous presence of small foods in the home and the lack of an efficient grinding surface before the eruption of the back molars could explain the high propensity for choking in this age group.[18] In 1979, the US Consumer Product Safety Commission passed regulations to control marketing of nonfood items that are threats to cause choking in infants and children. [19] Since that time, additional legislations here increased the requirements for the display of choking-hazard labels on products containing small parts.[20, 21] Small toys, rubber balloons, nails, tacks and bolts are the main offenders. [22] Other dangerous objects include earrings, straight pins, aluminium foil, rocks and other small metal objects.[23-27] Especially worrisome are rubber balloons, now the leading cause of pediatric choking deaths from children's toy products.[28] Several features of balloons explain why they are so dangerous. Their collapsibility allows them to pass through the vocal cords and lodge in the carina. In addition, their inflatability prevents any air passing through to the lungs. Many communities have directed efforts to prevent childhood deaths from choking on balloons by banning rubber balloons in daycares, schools and hospitals. Other communities are proponents of safer non-rubber balloon alternatives.

Foreign Objects In the Nose:

Foreign objects are commonly placed by young children into their nose. The classic presentation of an unexplained foul smelling nasal discharge which is unilateral and persistent is common in unwitnesed events. Other less specific symptoms include chronic sinusitis, recurrent epistaxis and halitosis.[29-32] Frequently the presenting complaint is that the parent witnessed the young child place the object in the nose. The removal of these nasal foreign bodies is generally straightforward with adequate visualization and appropriate instruments necessary for a successful removal. Visualization may be improved with applying a topical vasoconstrictor to the nasal mucosa, using a high intensity light source and using suction to remove any nasal secretions. Complications include trauma to the nasal mucosa, potential fracture to the cribriform plate and potentiating aspiration of the foreign body into the proximal airway.[29, 30]

Maneuvers To Remove Upper Airway Foreign Bodies:

Certain assumptions underlie the current recommendations for treatment of airway obstruction in children and infants. Although cardiac arrest with secondary airway obstruction is often seen in adults, in infants and children airway obstruction with secondary cardiac arrest is much more common. A foreign body that completely obstructs the upper airway is an immediate threat to life and must be removed immediately. However, if the child can speak or breathe or is coughing, the foreign object may dislodge spontaneously, making any first aid maneuvers potentially detrimental by converting a partial airway obstruction into a complete airway obstruction. Partial airway obstruction with very poor air exchange, or complete airway obstruction with cyanosis requires immediate interventions to avoid permanent disability or death.

Which maneuver is used to relieve an upper airway obstruction depends on the age of the child. The pediatric and emergency medicine community, including the Committee on Pediatric Emergency Medicine of the American Academy of Pediatrics (AAP), the American Heart Association (AHA), and the Red Cross, consider the abdominal thrust maneuver the most effective method of relieving complete airway obstruction in children older than 1 year of age.[33, 34] The utility of this maneuver based in the following principles: eighty percent of respiratory effort is from diaphragmatic contraction, abdominal inward pressure compresses the diaphragm upwards thus raising intrathoracic pressure, and a sudden rapid increase in intrathoracic pressure may expel the obstructing object.[34] As the victim becomes hypoxic from obstruction, muscle tone diminishes thus making the abdominal thrust maneuver more effective.

The AAP and AHA recommend the head-down back-blow maneuver followed by the chest-thrust maneuver for relieving airway obstruction in the child younger than 1 year of age. Some experts prefer the abdominal thrust maneuver for this age group as well as the older child and no studies deny its effectiveness. However, critics of using this maneuver in the child less than 1 year of age, cite cases of ruptured abdominal organs, pneumomediastinum and even a thrombosed aorta.[35-37] Possible explanations for these complications in children less than one year of age is that 70% of abdominal thrust maneuver in infants were performed by untrained individuals and 50% of the time these maneuvers were performed by people who learn of this technique by reading newspapers and lay magazines. Additionally infants have relatively large

stomachs, livers and spleens as compared to older children. This anatomical difference could contribute to the higher complication rate of the abdominal thrust maneuver in infants.

Another argument against using the abdominal-thrust maneuver in an infant or young child relates to the increased compliance of the infant's chest wall compared with that of the older child. Because of this compliance the infant's chest wall absorbs some of the energy from the abdominal-thrust maneuver, resulting in chest wall expansion at the expense of lung expansion.[38] This can make the abdominal thrust maneuver in the infant less effective than in the older child by not producing pressure changes significant enough to expel the foreign object from an obstructed airway.[38]

The head-down back-blow maneuver, the first step recommended for infants, combines the force of gravity with the force the chest compression generates to expel intrathoracic air. Some investigators are concerned that the sudden air acceleration associated with the back blows may cause an object to paradoxically travel rather into the airway. Indeed, studies indicate that the back-blow maneuver may make the object move caudally in accordance to Newton's third law of motion, "to every action there is always an equal reaction."[39] In a patient who is awake, back blows also can cause the airway to open or reconfigure slightly, forcing the foreign body further into the airway and worsening the obstruction. In the face-down infant who is unconscious, this appears to be less relevant.

In controlled experiments on a closed system comparing the abdominal-thrust maneuver with the back-blow maneuver, the generated intrathoracic pressures were 13 mm Hg for the abdominal thrust maneuver and 32.5 mm Hg for the back-blow maneuver.[40] Conversely, in another controlled experiment, the abdominal-thrust maneuver generated and average maximum pressure of 21 mm Hg compressed with 11 mm HG for the back-blow maneuver.[40] The pressure response persisted much longer with the abdominal-thrust maneuver (0.7 seconds) than with the back-blow maneuver (0.01 seconds).[40] These contradictory findings make the scientific proof of the efficacy of the abdominal thrust maneuver less clear.

The second step recommended for infants, the chest-thrust maneuver, uses sternal compression to increase intrathoracic pressure in an effort to expel the foreign object from the airway. These compressions are similar to those performed for cardiopulmonary resuscitation. The rescuer uses two or three fingers to compress the sternum approximately one-third to one-half the depth of the chest. This corresponds to a depth of about ½ to 1 inch, although these measurements are often not precise. The chest compressions theoretically can inflict rib and cardiac damage in infants, but a study designed to investigate this possibility found no significant rib injuries or fractures in a large review of infants who underwent chest compression, and no such injuries are reported elsewhere in the literature.[41]

Blind finger sweeps of the oropharynx to remove a foreign body that cannot be visualized should not be performed. Attempt to remove a foreign body only if it is visible.[33] In administering chest compressions or subdiaphragmatic abdominal thrust for the unconscious, nonbreathing child, open the child's mouth by grasping both the tongue and the lower jaw between the thumb and fingers and lifting, thus performing a tongue-jaw lift procedure. This action draws the tongue

away from the back of the throat to eliminate the possibility of the tongue causing a partial airway obstruction.

If the back blows, abdominal thrust or chest thrust are unsuccessful in the nonbreathing, unconscious victim, removal of the foreign body should be attempted. This optimally would be performed in a controlled setting such as the emergency department under direct visualization using laryngoscopy with forceps. If the foreign body is visualized, extraction using Magill forceps would be the procedure of choice. Endotracheal intubation may force the foreign body distally enough to partial ventilated and more importantly oxygenate the child. The pop-off valve of the bag-valve system should then be occluded enough to deliver sufficient volume of oxygenation and ventilation. If these attempts fail, the physician should proceed to create a surgical airway.

Lower Airway Foreign Bodies:

As the foreign body passes through the vocal cord into the trachea and bronchi, acute symptoms of choking, gagging and distress may resolve thus making the diagnosis more difficult. The common clinical triad of cough, wheezing and decreased breath sounds in children with foreign bodies in their lower airway is not consistent. Between 50% and 90% of children with foreign body aspiration have a suggestive history, most commonly of an acute episode of paroxysmal cough.[3,6,7,14,42-44] Other common symptoms that occur at the time of aspiration are cyanosis, choking and dyspnea.[3,7,44,45] In addition, the symptoms of these patients mimic many other pulmonary conditions including asthma, bronchiolitis and pneumonia.[6,8,11,46] Only half of all children are diagnosed correctly in the first 24 hours after a choking episode and an additional 30% receive the correct diagnosis in the following week.[5,10,14] The remainder may have delays in diagnosis of weeks to years.[5,7,9,10,14,49] Delayed diagnosis is associated with a number of complications, such as pneumonia and atelectasis, and one study found bronchiectasis in 25% of patients diagnosed greater than 30 days after their aspiration event.[47] For these reasons, the clinician must have a high index of suspicion in order to diagnosis an aspirated foreign body in the lower airway. The most common foreign bodies retrieved from the lower airway are foods, nuts, and seeds.[48] The most common inert foreign objects retrieved form the lower airway are toys.[48]

Radiographic Studies:

Diagnostic imaging plays a variable role in identifying foreign bodies in the lower airway. Since the majority of foreign bodies in the lower airway are food, they are not radiopaque and usually are not apparent radiographically. However, appropriate radiographic studies can aid in localizing the site of the foreign body in the lower airway.[5-8,14,46,49-51] Radiographic evaluation in the emergency department should start with AP and lateral views of the chest and neck. Differential inflation of the affected lung is the most common abnormality identified. This differential inflation may be accentuated by fluoroscopy, lateral decubitus films or assisted expiratory views.[3,6,7,14,15,50,52,53] The lateral decubitus film and the assisted expiratory views accentuate the ball-valve mechanism of the partial obstructive bronchial foreign body, leading to residual hyperinflation of the involved lung and sometimes mediastinal shift toward the unaffected side. In children too young to cooperate, the lateral decubitus view may simulate an

expiratory film, however, two studies have shown little added diagnostic benefit from these studies.[54, 55] Resorption atelectasis beyond the site of an airway foreign body and the presence of pulmonary infiltrates are other indirect signs of foreign bodies in the lower airway.[3,5-7,14] Although CT scan, xeroradiography and ultrasonography have been advocated for foreign body imaging in the lower airway, their utility has yet to be demonstrated.[3,56] For localizing peanuts and other seeds in the airway, MRI has been suggested as an appropriate imaging modality.[57] Given the limited sensitivity of radiographic findings in children who have aspirated foreign materials into their lower airways, clinical judgment must dictate whether children should be scheduled for diagnostic bronchoscopy in the face of negative radiographic studies.[53-55]

Management:

The majority of children presenting to the emergency department with foreign bodies in their lower airway are not in extremis. Administration of supplemental oxygen and close observation with monitoring are usually all that is required in the stable patient. As reviewed earlier if the foreign body is in the pharynx and can be easily visualized and the child's cooperation can be enlisted, the foreign body may be safely removed in the emergency department using appropriate instruments. In the vast majority of cases, airway foreign body removal is best achieved in the operating suite. Rigid bronchoscopy under general anesthesia is the procedure of choice for removal of most foreign bodies of the trachea or bronchi.[3,5-7,15,49,50,58] The availability of a fiberoptic-telescope system with a ventilating bronchoscope enables ventilation and instrumention to occur simultaneously. Flexible bronchoscopy has also been shown to be effective, and may be considered as first-line therapy in some institutions.[59,60] Other less accepted methods include the use of a Fogarty balloon catheter in conjunction with a rigid bronchoscope to facilitate removal of the airway foreign body.[50,52] Postural drainage with percussion is thought to be potentially dangerous and its use is discouraged.

Post bronchoscopy complication rates range from 2% to 8%, with the most common complications including subglottic edema from the endoscopic procedure and residual lung atelectasis.[8,15,52] Flexible fiberoptic bronchoscopy is not indicated in the removal of foreign objects from the lower airway. Reasons include inability to administer anesthetic agents, inert potential for further airway compromise and greater difficulty in controlling instruments.[45,49,53,58] Excessive pressure or biting motions upon removal of the foreign body may lead to fragmentation and further morbidity. Sharp objects should be removed within the lumen of the scope to minimize mucosal injury. In the rare occurrence that the patient is so unstable that general anesthetic is not indicated, topical anesthetic and restraints could be used to remove tracheal or bronchial foreign bodies.[53,58,61] Open thoracotomy is indicated when rigid bronchoscopy fails or when objects are tightly impacted.[5,7,49]

Conclusion:

Regulatory changes and increased public awareness have reduced the number of choking deaths, but foreign bodies in the airway still remain a significant problem. Tragic outcomes will only be reduced when primary care physicians stress to their patients, their patient's families, and the communities the importance of prevention through anticipatory guidance. The appropriate maneuvers of relieving foreign body airway obstruction should be taught to parents and

caretakers. Additionally, in an emergency department setting, laryngoscopy and forceps extraction must be rapidly undertaken when indicated. Aspirated foreign bodies in the lower airway require the clinician to have a high index of suspicion in order to make a timely diagnosis. Finally, it is important to remember, if one foreign body is found in the respiratory tract, always look for others.

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