

Review Article

Airway foreign bodies: A critical review for a common pediatric emergency

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BACKGROUND: Airway foreign bodies (AFBs) is an interdisciplinary area between emergency medicine, pediatrics and otolaryngology. It is a life-threatening condition that is not infrequently seen; however, it is poorly covered in medical literature. Accidental aspiration of an element into airways is a widespread clinical scenario among children under 3 years, predominantly males. Moreover, it is the leading cause of infantile deaths and the fourth one among preschool children.

DATA RESOURCES: A systemic search was conducted in July 2015 using PubMed/Central Database of The National Center for Biotechnology Information (NCBI) (<http://www.ncbi.nlm.nih.gov/>). A total of 1 767 articles were identified and most of them were meta-analyses, systematic reviews, and case series. Those thoroughly discussing assessment and management of AFBs were retrieved.

RESULTS: AFBs episodes may be either witnessed or missed. Presence of a witness for the inhalation is diagnostic. The later usually present with persistent active cough. A classical triad of paroxysmal cough, wheezing, and dyspnoea/decreased air entry was reported, though many presentations have inconsistent findings. Hence, diagnosis requires high index of clinical suspicion. Flexible fibro-optic bronchoscopy is the gold standard of diagnosis, whereas inhaled objects are best retrieved by rigid bronchoscopes.

CONCLUSIONS: Close supervision of pediatrics is the hallmark of prevention. Caregivers should ensure a safe surrounding milieu, including the toys their offspring play with. Immediate complications result from direct obstruction or injury by the inhaled object. Alternatively, prolonged lodging traps air and induces inflammatory response causing atelectasis and pneumonia, respectively.

KEY WORDS: Airway foreign bodies; Aspiration/inhalation; Airway obstruction; Café coronary syndrome; Breathing difficulties

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INTRODUCTION

Accidental impaction of objects in the respiratory tract, known as airway foreign bodies (AFBs), is a potentially life-threatening emergency; however, it is a poorly covered topic in textbooks. The most common site for that is the right lower bronchus or its bronchus intermedius as it is more vertical, shorter and wider.^[1]

Historically, Haugen^[2] was the first to report a series of deaths in restaurants in 1963. Café coronary is a fatal upper airway obstruction that occurs to adults who spontaneously swallow large pieces of meat while they laugh or chat. Such cases were successfully managed in 1897 using bronchoscopic extraction by the pioneer Gustav Killian.^[3]

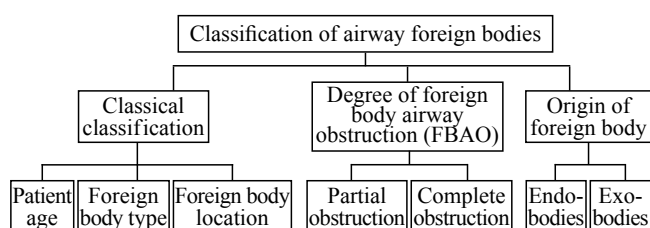


Figure 1. Classification of airway foreign bodies.

Classification

Despite of its importance, no standard classification system for AFBs exists. Rather, there are several items to categorize them, here are the most important three. In classical classification, cases are differentiated according to patient age, foreign body category, and the impaction site.^[4] According to the degree of foreign body airway obstruction (FBAO), there are two types, partial and complete obstruction. The former has mild to moderate effects compared to consequences of complete occlusion. Regarding the origin of foreign bodies it is either internal or external. Examples of endogenous sources include mucus masses (mucocoele)^[5] and bronchial casts of plastic bronchitis. Exogenous bodies are like industrial items, e.g. plastic bags, small items, etc and food particles as peanuts that are seen in 40% of all cases.^[6]

Epidemiology

Thus so far, statistic data are mainly retrieved from single center studies. Larger cohorts and national wide analysis have just started.^[7] These studies estimate the incidence of FBAO to be 0.66 per 100 000.^[8] In the USA, 17 000 emergency visits in children under 14 years were attributed to foreign bodies inhalation during 2000.^[9] Moreover, it is the leading cause of accidental infantile deaths and the fourth one among preschool children (≤ 5 years).^[10]

AFBs have very unique demography. 80% of cases are below 3 years, of which the peak frequency occurs in 1–2 years age group.^[11] In a review of 81 cases, Asif et al found that 77.8% of foreign bodies are aspirated by children under 5 years, 16% by children between 5–15 years, and 6.2% by those above 15 years. Similarly, Reilly et al^[12] highlighted that ≤ 4 years pediatrics are more vulnerable to inhale bodies as they are driven by oral exploration behavior using their molar-free mouths and they lack well-coordinated swallowing reflex. The smaller diameter of their airways allows the inhaled body to obstruct the tract.^[13] Additionally, Yadav et al^[14] and Brkić and Umihanić^[15] demonstrated that 46% and 65.2% of their sample were ≤ 3 years, respectively.

Male sex predominance is another characteristic feature of this condition.^[16] Their adventurous and impulsive behavior may justify that.^[17] In a study done by Cohen et al,^[18] male to female ratio was 1.4:1.0. Kaur et al^[19] and Hughes et al^[20] found it to be 1.5:1.0 and 1.7:1.0, respectively. Furthermore, Shlizerman et al^[21] reported that up to two thirds of their patients were boys. The incidence in Arab children was significantly higher than that in their Jewish peers in Israel ($P=0.001$). To the best of our knowledge, this is the first study to report racial differences.

The socioeconomic status has a limited impact on the burden of AFBs, rather, it is associated with a high incidence of serious complications seen in high (10%) and low-middle income countries (20%).^[22]

Type of inhaled foreign body has global variation. For example, 91% of western patients inhaled organic materials, peanuts account for half of that.^[23] However, bones were the most common AFBs in southeast Asia and China.^[24,25] Similarly, seeds of watermelons, sunflowers, and pumpkins are more prevalent in Egypt, Turkey, and Greece, respectively.^[26]

This is because of differences in food habits that reflect a cultural impact. Moreover, religion and associated habits have some role to play. Ragab et al^[27] reported 20 Muslim females who accidentally aspired scarf pins held between their lips while wearing Hijab. Obviously, treating pins orally, rather than Hijab itself, was the why.

Etiology

Causes vary greatly depending on age. While children tend to explore their surroundings, they may engulf some inappropriate objects. For instance, toys, coins, etc should not be treated by mouth. Some types of food require higher level of skills to deal with which makes it age-restricted, i.e. peanuts for preschool children who lack the necessary skills of mastication.

Children are choked by food while moving or talking relatively resembles the scenario of café coronary in adults. Pediatrics are known for their physical activity, this may disrupt their concentration and increase both respiratory rate and depth leading the food into the respiratory passages.

Finally, AFBs may occur because of misdirecting of solid food or liquid fluids into the airways rather than the gastrointestinal tract during the second stage of deglutition, the pharyngeal stage.^[28] Alternatively, an endogenous source may obstruct airways as seen in case of mucoid impaction or bronchial casts

formation characterizing plastic bronchitis.^[29] The exact pathophysiological mechanism is unknown, but it is commonly seen in chronic asthmatics, adults with cardiac and pericardial diseases, and children with congenital heart deformities.^[30]

Pathophysiology

Nature of the foreign body determines the degree of inflammatory response. Metallic objects cause minimal reaction, while lipophilic materials stimulate intense chemo-inflammation in a response to its fatty acid content.^[31] Starchy food adsorbs water, turning partial obstruction into complete one.^[32]

Clinical features

Onset of symptoms is predominantly sudden. These presenting complaints depend widely on the location where the body lodged. Nasal objects tend to cause unilateral, offensive, and chronic discharge that is usually unexplained.^[33] Rarely, cases of halitosis, chronic sinusitis and recurrent epistaxis have been reported.^[34-37]

Inhaled foreign objects induce prompt gagging, choking, and distress as they pass down through the vocal cords and epiglottis.^[33] Tracheal bodies have this clinical triad: asthmatoïd wheeze, audible slap from the rubbed trachea, and palpable thud.^[38] Penetration syndrome, i.e. choking and intractable coughing followed by vomiting characterizes endobronchial bodies.^[30]

Clinical features vary according to the wide range of symptoms. The suggested clinical triad of paroxysmal cough, wheezing and decreased air entry was seen in 35% and 39% of patients reported by Mehta et al^[39] and Denny et al^[40], respectively. Furthermore, Pinzoni et al^[41] demonstrated that cough and dyspnoea were the most presenting complaints. Likewise, the most frequent symptomatic triad according to Chiu et al^[17] was cough (72%), dyspnoea (64%) and wheezing (60%). The former acts as a protective reflex that keeps the inhaled body from advancing further.

In a study by Pinto et al^[42], a higher proportion of patients complained of cough (87.1%), whereas choking, fever and cyanosis were seen in 85.1%, 22.6% and 16.1%, respectively. According to Chew and Tan,^[43] the former two constituted 61.5% and 46.2%, respectively. They noted that, choking is usually missed or downplayed by parents as a principal complaint. Despite its low incidence, interestingly, choking showed a sensitivity of 81% and a specificity of 33%, when compared with

persistent coughing (a sensitivity of 78% and a specificity of 37%).^[44] Even though, another study found choking values to be as high as 97% for the sensitivity and 63% for the specificity.^[45] Occasionally, AFBs precipitate anxiety and ptalism as a result of sympathetic stimulation and psychoactive drive.^[46]

Notably, physical examination of symptomatic patients has a sensitivity of 90%.^[47] Clinical findings include raspy respiration, hypopnea, and dyspnea,^[48] accordingly, hypoxia, hypercapnia, and cyanosis develop. Additionally, ipsilateral wheezes may be appreciated on auscultation. Sonorous rhonchi, a special high pitched wheeze, indicates aspiration of a large foreign body.^[49] Interestingly, AFBs have a unique type of stridor that is expiratory and it indicates a lower tract obstruction.^[50]

Differential diagnoses

A long list of differentials should be considered. These diseases could be categorized according to the site of obstruction. Laryngeal bodies partially resemble subglottic laryngitis and epiglottitis.^[51] Presentations of foreign bodies lodging in the trachea mimic that of croup, tracheal and paratracheal compressing mass lesions, tracheomalacia, and tracheal stenosis. Bronchial obstructing bodies resemble congenital cystic adenomatoid malformation (CCAM), bronchial compression, and plastic bronchitis, also known as fibrinous, pseudomembranous, Hoffman's, or cast bronchitis.^[52] Bronchioles obstructing diseases as bronchiolitis, bronchiectasis, bronchiolitis obliterans, and bronchiolitis obliterans with organizing pneumonia (BOOP) should be considered. Lobar obstruction may be overseen as asthma and atelectasis.

Diagnosis

Diagnosis of AFBs is a real dilemma. Recently, Heyer et al^[53] developed diagnostic criteria. Two out of the following three are considered diagnostic and recommend bronchoscopy for confirmation: foal hyperinflation ($\beta=45.4$; 95%CI 5.3-390.5, $P=0.001$), witnessed choking crisis ($\beta=18.6$; 95%CI 4.7-73.0, $P=0.001$), leukocytosis $>10\ 000$ ($\beta=4.2$; 95%CI 1.2-14.7, $P=0.026$).

Another diagnostic tool is the scoring system created by Kadmon et al.^[54] Significant parameters are: age (10-24 months); history of presence of an object in patient's mouth followed by severe respiratory symptoms; signs of stridor, dyspnea or hypoxia during acute phase; unilateral abnormal breathing sounds on auscultation; abnormal

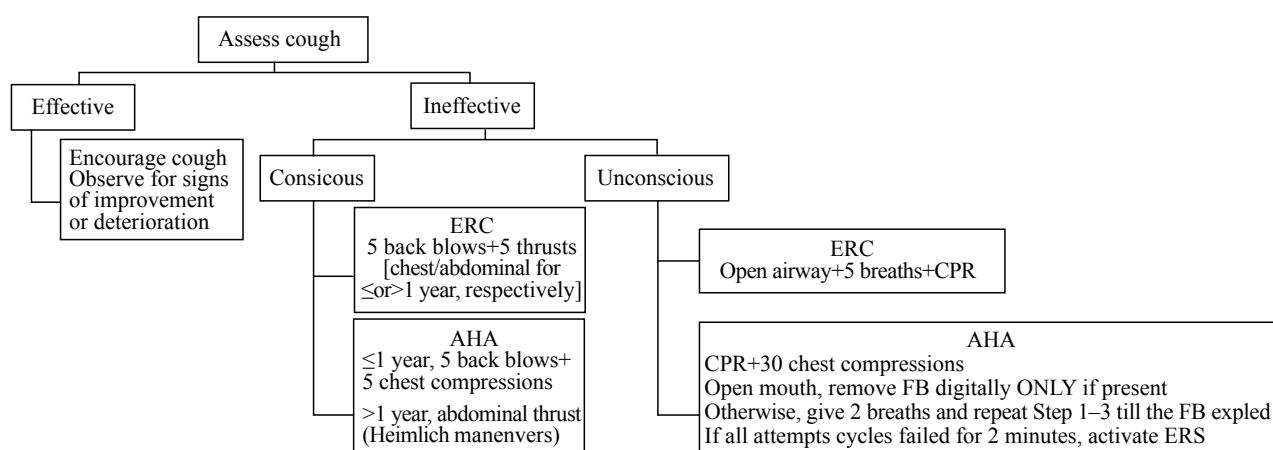


Figure 2. AFB emergency algorithm following ERC and AHA guidelines. ERC: European Resuscitation Council; AHA: American Heart Association; FB: foreign bodies; CPR: cardiopulmonary resuscitation; ERS: emergency response system.

tracheal radiogram; and positive chest X-ray (CXR).

Only 16% of AFBs are spot diagnosed on CXR as they are radiopaque.^[55] Accordingly, a negative film does not exclude aspiration, rather, it may contain one of the signs detected in 72% of the cases.^[56] This ratio was 67.7% in the study conducted by Svedstrom et al.^[57] Such radiological findings include unilateral atelectasis, local hyperinflation or obstructive emphysema. Usually, inspiratory-expiratory film in anterior-posterior (AP) view is likely to reveal the overinflation as a hyperlucency best during expiration.^[58] Although, lateral decubitus is routinely obtained, a recent study has demonstrated its limited role in diagnosis with only a sensitivity of 27% and a specificity of 67% (95%CI 0.1–5.2; $P=0.57$).^[59] Virk et al^[60] recommended addition of lateral soft tissue neck X-ray in case of laryngeal bodies.

Chest fluoroscopy is valuable in detecting mediastinal shift and paradoxical diaphragmatic respiration; however, its false negative rate of 53% is considerably high.^[61] Although, the diagnostic yield of CT scan is superior to that of CXR particularly for radiolucent bodies (a sensitivity of 100% and a specificity of 66.7%),^[62,63] it is the last resolve as it contradicts the contemporary approach for minimizing ionizing irradiation exposure. High quality scans require movement restriction, which makes it impractical choice for AFBs pediatric patients under respiratory distress. Hence, flexible fibro-optic bronchoscopy remains the gold standard for diagnosis. Baseline investigations, as complete blood count (CBC) and serum electrolytes, are useful in assessing patient's general condition. Pulse oximetry and arterial blood gases are of help in determining arterial blood oxygen saturation (SaO₂).

The key to reach a definitive diagnosis lies in a

detailed history that identifies risk factors, an examination that elicits important signs, and supportive CXR findings. Diagnostic bronchoscopy should be performed when any one of the above modalities is positive. Otherwise, both examination and radiography should be repeated 24 hours apart given a negative history and inconclusive initial examination and imaging in a stable patient.^[64]

Management

The management plan depends on many factors that include the general condition of the patient, clinical settings, and policy guidelines of the health facility. American Academy of Pediatrics recommendations offer a comprehensive approach to improve anticipatory measures.^[65] Caregivers must know the best ways of supervising their kids in a safe milieu. However, when precautions fail and aspiration is suspected or witnessed, parents should call 911 (ambulance service) asking for help. Meanwhile, basic life support manoeuvres should be started. Both European Resuscitation Council and American Heart Association guidelines are combined in Figure 2.^[66,67]

In hospital, while the above measures are checked, emergency bronchoscopy should be prepared. Flexible bronchoscope is used primarily for diagnosis. However, new studies defined a new role for them in treatment, particularly, when combined with ureteral stone baskets and forceps.^[68] When done by expertise hands, objects are retrieved in more than 90% of cases.^[69,70] Both Ramirez-Figueroa et al^[71] and Tang et al^[72] found this to be 91.3% in their two separate studies.

Rigid bronchoscopy is the modality of choice in extracting AFBs. It offers adequate visualization making them overweigh flexible ones by being dual-purpose,

diagnosis and management. Moreover, it is specially designed to enable anesthetists of administering oxygen and inhalational agents through the side arms. Additionally, it can be used with a wide range of instruments, like Roth nets and endoscopic baskets, to achieve better outcome.^[73] Its success rates range from 95% to 99%.^[74–76] Solanki et al^[77] suggested use of Heimlich's maneuver in tandem with bronchoscopy when it fails. Invasive operations such as tracheostomy, thoracotomy and bronchostomy are the options for the remaining 0.3%–4%.^[78–79]

Type of anesthesia is another issue of controversy. There is a wide consensus on using sevoflurane or halothane as inhalational agents for induction of anesthesia and spontaneous breathing as a maintenance technique of choice.^[80] This is usually done by connecting Ayre's T-piece (Mapleson F) to bronchoscope's sidearm. Alternatively, a single trial found positive pressure ventilation after paralyzing the patient to be superior since fewer episodes of coughing and desaturation were reported.^[81]

Postoperative hospitalization depends on clinical situation. According to Hidaka et al,^[82] the nature of inhaled body was the only predictor of recovery and subsequently hospital stay. For instance, patients who underwent bronchoscopic extraction of peanuts or animal materials were hospitalized longer than others (*OR* 5.80; 95%*CI* 1.12–30.43). In contrast, age, sex, and length of duration precedes intervention have no association.

Complications

Williams et al^[83] classified complications into minor complications such as arterial oxygen desaturation, bradycardia, and bronchospasm. Major consequences include laryngeal edema, pneumothorax, and cardiac arrests. Early diagnosis and adequate management are essential in preventing progression into serious consequences.^[84] Sharp objects cause serious injuries and subsequently hemoptysis. Prolonged airways obstruction precipitates hypoxia and hypercapnia. Recurrent irritation of alveolar epithelium develops edema that may be superadded by secondary bacterial infection. Longstanding inflammation leads to abscess formation, recurrent pneumonia, bronchiectasis, and bronchial strictures. Bronchial granulomas commonly surround vegetable matters and can be distinguished microscopically by presence of foreign body giant cells.^[85]

Reports on frequencies of complications and

mortalities are of great variety. This may be a result of their frequent underestimation in many studies.^[86] Inflammatory responses, localized edema, and bronchospasm are the most common consequences for AFBs. The 59.4% of patients reported by de Sousa et al^[87] had localized inflammations, whereas laryngeal edema and pneumonia were seen in 18.9%. The mortality rate was zero. A recent study found that pneumonia (32.2%), granuloma (26.9%) and mucosal erosion (16.11%) were the most common complications.^[88]

Kaur et al^[89] reported that 10% of subjects developed complications predominantly as bronchospasm (8%) and subglottic edema (2%). They reported a death rate of 2% which was higher than that (0.42%) reported by Fidowski et al.^[90] Other complications have been shown in a huge meta-analysis of 1 699 papers.^[91] Among the complications reported in 15% of patients, laryngeal edema (9.3%), cardiac arrest (2.1%), and pneumothorax (0.7%) were the most serious. Rarely reported complications include brain abscess^[92,93] and pulmonary botryomycosis.^[94]

In conclusion, global population explosion and pacing lifestyle strongly favour AFBs. Careful supervision of children is the root reason of preventing inhalation. However, when precautions fail, a prompt intervention will minimize long-term complications. AFBs should be considered as a differential in any young child with unexplained cough.

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