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ASSESSMENT AND MANAGEMENT OF FOREIGN BODY ASPIRATION IN CHILDREN - A NARRATIVE REVIEW

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ABSTRACT

Foreign body aspiration is a significant cause of morbidity and mortality in the paediatric population. It is also a relatively common presentation in children, especially those under the age of 3 years old. Prompt recognition and management are essential to prevent life-threatening airway obstruction and long-term pulmonary complications. However, the diagnosis of foreign body aspiration remains a significant clinical challenge due to non-specific presentation and high variable physical examination findings. Typically, chest radiography is a first-line radiological investigation in children presenting with suspected foreign body aspiration. However, it is associated with poor sensitivity and specificity for diagnosing foreign body inhalation. Chest computed tomography provides improved sensitivity and specificity, however, it may still fail to identify small or organic foreign bodies. Its use in clinical practice is also limited by the need for patient sedation and exposure to high doses of radiation. Flexible and rigid bronchoscopy are central to both definitive diagnosis and treatment, with rigid bronchoscopy being considered as the gold standard for foreign body retrieval. Early diagnosis and timely intervention are associated with improved outcomes and reduced complications in pediatric patients.Foreign body aspiration is a significant cause of morbidity and mortality in the paediatric population. It is also a relatively common presentation in children, especially those under the age of 3 years old. Prompt recognition and management are essential to prevent life-threatening airway obstruction and long-term pulmonary complications. However, the diagnosis of foreign body aspiration remains a significant clinical challenge due to non-specific presentation and high variable physical examination findings. Typically, chest radiography is a first-line radiological investigation in children presenting with suspected foreign body aspiration. However, it is associated with poor sensitivity and specificity for diagnosing foreign body inhalation. Chest computed tomography provides improved sensitivity and specificity, however, it may still fail to identify small or organic foreign bodies. Its use in clinical practice is also limited by the need for patient sedation and exposure to high doses of radiation. Flexible and rigid bronchoscopy are central to both definitive diagnosis and treatment, with rigid bronchoscopy being considered as the gold standard for foreign body retrieval. Early diagnosis and timely intervention are associated with improved outcomes and reduced complications in pediatric patients.

KEYWORDS

Foreign Body Aspiration, Foreign Body, Flexible Bronchoscopy, Rigid Bronchoscopy, Tracheobronchial Foreign Body, Computed Tomography, Airway Obstruction

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1. Introduction

Foreign body aspiration is a common presentation in the paediatric population and a significant cause of morbidity and mortality in children. Young children are particularly at risk of foreign body aspiration, with the majority of events occurring in children younger than 3 years old. Accurate diagnosis can be challenging as the clinical presentation is highly variable, ranging from an episode of acute respiratory distress to more subtle and non-specific symptoms. This variability in presenting symptoms often leads to a delayed diagnosis or misdiagnosis as other respiratory conditions such as asthma or pneumonia. A foreign body can obstruct the airways, leading to problems with ventilation and oxygenation. In severe cases this might lead to severe complications and even death through the mechanism of hypoxic-ischaemic brain injury or pulmonary haemorrhage (1). Prompt and timely management of foreign body inhalation is crucial to avoid potentially life-threatening complications. Studies suggest that 85% of cases with foreign body aspiration are diagnosed on time, however, the remaining 15% of patients with delayed diagnosis are at higher risk of developing serious complications such as pneumonia, atelectasis or abscess (2). In the United States, it is one of the leading causes of accidental deaths in children under the age of 6 (3). The estimated incidence of foreign body inhalation in children is 29.9/100,000, and it was reported as a cause of death in 160 cases in the United States alone in 2000 (4). This narrative review aims to provide a comprehensive overview of the assessment and management of foreign body aspiration in children, integrating current evidence to support clinical decision-making.

2. Epidemiology and risk factors

Foreign body aspiration is most common in children aged 1-3 years old. Epidemiological data indicate a slight male predominance. Infants and toddlers are at increased risk of foreign body inhalation due to the lack of molar teeth, the tendency to put little objects in their mouths, other behavioural tendencies and immature airway protective reflexes (5). The most commonly reported inhaled objects include organic materials such as nuts, seeds and other food particles, with peanuts being the most frequently aspirated objects. Aspiration of inorganic materials is less common, and within this group stationery items are most commonly inhaled The right main bronchus is usually considered to be the most frequent site of lodgement of the foreign body within the tracheobronchial tree due to its more vertical orientation and wider diameter compared to the left main bronchus (4). However, various studies reported conflicting results, with the frequency of foreign body lodgement in the right/left bronchus ratio recorded ranging from 60%/40% (6) to 48%/52% (7). Lodgement of the foreign body in the larynx or trachea is less commonly reported. Globally, foreign body aspiration accounts for approximately 7% of accidental deaths in children under three years, which highlights its importance as a public health issue (8).

3. Clinical presentation

Presenting symptoms are highly variable and include sudden onset of cough, dyspnoea, wheeze, cyanosis, stridor and acute respiratory failure (9). However, a study by Raviv et al. reported that an episode of witnessed choking or coughing cannot reliably predict foreign body aspiration and that symptoms suggestive of other pathology, such as fever or rhinorrhoea, do not reliably exclude this diagnosis (10). The type of presentation is heavily dependent on the location of the foreign body within the tracheobronchial tree, the type of inhaled object, the degree of airway obstruction as well as how quickly medical attention is sought after the event (11). Presentation is often preceded by an episode of acute respiratory distress or obvious choking, although it can also present in a more sinister way. In some cases symptoms can be more subtle, such as persistent cough, recurrent pneumonia or persistent unilateral wheeze, which might lead to delayed presentation and diagnosis. Studies suggest that up to 30% of children with foreign body aspiration might be misdiagnosed due to the non-specific presentation, most commonly as other respiratory diseases such as bronchiectasis, bronchitis, asthma or pneumonia. Clinical signs, if present, are typically non-specific and include unilaterally diminished breath sounds, wheezing, crackles and rhonchi (12, 13). In a study by Petrova et al. (14) abnormal physical examination findings were present in 65% of patients with confirmed foreign body aspiration and abnormal lung auscultation was shown to be predictive of foreign body inhalation ($\chi 2 = 27.83$, $P < 0.00001$). However, whilst suggestive of foreign body aspiration, examination findings should always be interpreted together with clinical history and radiological results. Whereas history and clinical examination can provide some clues to the diagnosis, foreign body aspiration can only be reliably confirmed or excluded based on bronchoscopy findings. This was confirmed in a study by Genisol et al. which, with the use of machine learning techniques, aimed to identify one finding in a patient's clinical history that is most predictive of the diagnosis of foreign body aspiration in children. It was reported that a definitive diagnosis of foreign body inhalation is not possible based on clinical history, examination and chest x-ray findings alone. Additionally, it was suggested that, out of all findings in a patient's history, a witnessed episode of aspiration is the most predictive of a diagnosis of foreign body aspiration in children (11). However, most episodes of foreign body inhalation occur unwitnessed. Therefore, clinicians should have a high index of suspicion of foreign body aspiration in all children presenting with respiratory symptoms.

4. Imaging modalities

Radiological imaging is essential in the evaluation of children with suspected foreign body aspiration. Chest radiography remains the first-line investigation, although normal findings do not exclude foreign body aspiration. Chest CT, particularly low-dose multidetector CT, offers high diagnostic accuracy and is increasingly used in equivocal cases.

4.1. Chest radiography

Chest x-ray, preferably posteroanterior and lateral radiographs, is usually the first-line investigation in a child presenting with a suspected foreign body aspiration. However, chest x-ray sensitivity for diagnosing foreign body aspiration is poor and has been reported to be as low as 68%, with specificity of 67% (15),

whereas positive and negative predictive values have been reported to be as low 59% and 69%, respectively (14). The reported diagnostic accuracy was found to be as low as 67%, indicating that radiological findings alone are neither reliable nor sufficient to make a diagnosis (15). Unfortunately, the minority of inhaled foreign bodies are radiopaque., with the vast majority of inhaled foreign bodies being radiolucent and not easily identifiable on plain radiographs. The presence of a radiolucent foreign body in the airways can be suggested by secondary radiographic signs on chest x-ray, such as prominent bronchovascular markings, consolidation, air trapping on the affected side of the lung, atelectasis, mediastinal shift, pneumothorax and subcutaneous emphysema. Although chest x-ray results, when combined with abnormal physical examination, have been found to be correlated with foreign body aspiration diagnosis (14), radiological changes are present in only 72% of cases (16), rendering an accurate diagnosis of foreign body aspiration even more challenging. Therefore, a normal chest x-ray should not rule out the diagnosis of foreign body aspiration in children, especially in those who present with a suggestive history and abnormal clinical examination. Chest radiography might be helpful as an aid in the diagnostic process; however, it is neither sensitive nor specific for identification of foreign body aspiration. Thus, the diagnostic approach to a child presenting with suspected foreign body inhalation should integrate clinical history, physical examination as well as radiological findings.

4.2. Chest computed tomography

Chest computed tomography (CT) has emerged as a valuable diagnostic tool in the assessment of children with suspected foreign body aspiration, especially in equivocal cases. Its use in the diagnosis of foreign body aspiration has emerged as a way of reducing the number of unnecessary bronchoscopies. It does offer much higher sensitivity and specificity for the diagnosis of foreign body aspiration in children compared with chest x-ray. It often allows for precise identification of the location of the foreign body within the lumen of the tracheobronchial tree and it is also very sensitive at detecting associated secondary radiological findings, which include air trapping, consolidation, atelectasis, mediastinal shift or pneumothorax (15). A recent systematic review and meta-analysis by Goodarzy, B et al. (17) aimed to evaluate the diagnostic value of chest CT in identifying foreign body aspiration in children. Data search was performed using various databases including Medline, Scopus, and Web of Science from inception to May 2024. Following the evaluation of the eligibility criteria and removing the duplicates, a total of 26 studies were included in the analysis. The reported pooled sensitivity of chest CT for diagnosis of foreign body aspiration in the paediatric population was 0.99 (95% CI: 0.98-0.99) and the pooled specificity was 0.97 (95% CI: 0.96-0.98). The reported pooled positive and negative ratios were 10.12 (95% CI: 4.59-22.20) and 0.05 (95% CI: 0.02-0.1), respectively. The accuracy of chest CT for detection of foreign body aspiration was found to be excellent (0.98). A similar literature review by Tuckett et al. (18) assessed the accuracy and safety of chest CT in the diagnosis of paediatric foreign body aspiration and evaluated its use as a measure to reduce the number of rigid bronchoscopies. It analysed a total of 14 studies published between 1970 and 2013. Data search was conducted using copus, Web of Knowledge, Medline, and Embase. The reported sensitivity and specificity of chest CT for diagnosis of foreign body aspiration ranged from 90% to 100% and 75% to 100%, respectively. The reported average radiation dose was 2.16 mSv. Another systematic review and meta-analysis by Azzi et al. aimed to also assess the diagnostic accuracy of chest CT (19) and it included articles from Ovid MEDLINE, Ovid EMBASE, PubMed MEDLINE and Web of Science published from inception to January 2021. A total of 16 manuscripts were used in the analysis. The reported sensitivity and specificity of chest CT for the diagnosis of foreign body aspiration were 98.8% and 96.6%, respectively. The calculated radiation dose used during chest CT ranged from 0.04 to 2 mSv, 0.99-59.1 mGy-cm and 0.03-16.99 mGy, and was deemed acceptable. Evidence suggests that chest CT can effectively diagnose foreign body aspiration in children and might be helpful in reducing the number of unnecessary bronchoscopies, in particular when clinical suspicion of foreign body aspiration remains high despite a normal chest x-ray result. Nevertheless, the benefits of performing this radiological investigation should be carefully weighed against potential side effects and risks involved. The majority of children with suspected foreign body aspiration will require sedation to undergo chest CT to avoid motion-related artefacts. The use of sedative agents can be associated with complications such as upper airway obstruction, hypoventilation, hypoxia, hypotension as well as other more common side effects such as post-sedation nausea, vomiting, disorientation and sleep disturbance (20). The other factor to consider is exposure to high doses of radiation and its potential carcinogenic effect, which has been shown to be dose-dependent (21). Furthermore, the use of chest CT in the assessment of all children presenting with suspected foreign body aspiration has not been shown to be cost-effective (22). Therefore, it should not be used routinely in all children presenting with a suspected foreign body aspiration.

5. Definitive management

Currently, there is an ongoing debate regarding the choice between rigid and flexible bronchoscopy for the treatment of foreign body aspiration in children. According to the current guidelines, rigid bronchoscopy is considered the gold standard for definitive diagnosis and treatment, whereas flexible bronchoscopy remains an auxiliary option used as an aid to the diagnostic process (23).

5.1. Rigid bronchoscopy

Rigid bronchoscopy remains the method of choice used for confirmation of the diagnosis of foreign body aspiration and extraction of the foreign body from the tracheobronchial tree. Evidence suggests that it should be performed within 24 hours to minimise the risk of potential complications (24, 25). It is performed under general anaesthesia and allows for optimal airway control, direct visualisation of the airway and localisation of the foreign object and use of a wide range of extraction instruments. It is particularly effective for large, centrally located, or impacted objects (26). Various studies have shown that the percentage of negative bronchoscopies, where no foreign body is found in the tracheobronchial tree, ranges from 3.8% to 16%. Numerous studies have demonstrated high foreign body retrieval rates with rigid bronchoscopy, often exceeding 95%, if performed by an experienced clinician. However, it is a technically demanding procedure and can lead to serious complications such as bronchospasm, hypoxia, bleeding, bradycardia, tracheal injury, foreign body migration or death (27, 28).

5.2. Flexible bronchoscopy

Whereas current guidelines recommend rigid bronchoscopy for the removal of an aspirated foreign body from the airways, many studies have confirmed that flexible bronchoscopy is a safe, effective and widely accepted procedure. It has been identified as a less invasive alternative to rigid bronchoscopy and is associated with a lower risk of complications. It allows for both identification and extraction of foreign bodies from the airways. It is particularly useful in cases where a foreign body is lodged in the distal parts of the airways (29). A combined approach with the use of both rigid and flexible bronchoscopes is recommended in certain cases such as inhalation of small metal pins of slippery foreign bodies (30).

5.3. Rigid versus flexible bronchoscopy

The efficacy and safety of rigid and flexible bronchoscopy in the treatment of foreign body aspiration in children was compared in a systematic review and meta-analysis performed by Safia et al. (29). A literature search was conducted using PubMed, Scopus, Web of Science, Cochrane Library, and Google Scholar, from the inception of the databases to March 2024. A total of 14 studies were deemed eligible for data synthesis. The pooled meta-analysis did not show any significant differences in the success and failure rates of foreign body removal between rigid and flexible bronchoscopy. The analysis demonstrated a significantly higher rate of negative first bronchoscopy and a higher rate of conversion to the other method with the use of a flexible bronchoscope compared to the rigid bronchoscopy group. Additionally, it demonstrated a significantly shorter inpatient stay in the flexible bronchoscopy group. However, the overall complication rate was reported to be similar in the rigid and flexible bronchoscopy groups, with the risk of desaturation during the procedure being significantly higher in the flexible bronchoscopy group. Overall, both rigid and flexible bronchoscopy were found to be effective and safe methods in the treatment of foreign body aspiration in children. Nevertheless, due to the significant heterogeneity of the studies included in the meta-analysis, it was recommended that decisions regarding the use of rigid vs. flexible bronchoscopy for foreign body retrieval in children should be made on a case-by-case basis.

6. Complications

Foreign body aspiration can lead to both acute and chronic complications, such as bronchiectasis, recurrent pneumonia or respiratory infections, chronic cough, wheezing and pulmonary or segmental lung collapse (31). The risk of complications associated with foreign body aspiration is heavily dependent on how quickly the diagnosis is reached and the foreign body is removed. Any delays in diagnosis and treatment of foreign body aspiration can increase complications, morbidity and mortality rates. Many studies proposed that bronchoscopy should be performed in children within 24 hours of foreign body inhalation in order to minimise that risk (23). A recent retrospective cohort study in a paediatric tertiary centre looked at the complication rates in children with foreign body aspiration who underwent bronchoscopy either within 24 hours of the initial

event or outside that time frame. The study showed that the complication rates were higher in children who underwent bronchoscopy after 24 hours (37% and 22%, respectively). Delays in performing bronchoscopy in patients with foreign body aspiration were identified as mainly due to the fact that foreign body aspiration was not initially suspected. Moreover, the authors also demonstrated that the paediatric intensive care unit (PICU) admission rates were high (15%) in all children with foreign body aspiration, regardless of the timing of bronchoscopy (32). A study from China (33) showed a clear correlation between the length of time before the foreign body is removed and the duration of inpatient hospital stay ($r= 0.189$; $p<0.001$). Another study from Peru (34) described a statistically significant association between the timing of bronchoscopy in patients with foreign body aspiration and the length of hospital stay following the procedure, when adjusted for age, sex, type of foreign body and mouth sweep manoeuvre as a rescue measure (RR: 2.94, 95%, CI:1.72 – 5.01). Additionally, the type of inhaled foreign body might be relevant in terms of the risk of pulmonary complications. A retrospective review by Hidaka et al. (35), which analysed the risk factors for prolonged pulmonary recovery in children with foreign body aspiration, showed an association between aspiration of peanuts and animal material with the length of hospital stay (odds ratio, 5.80; 95% confidence interval, 1.12-30.43).

7. Conclusions

Foreign body aspiration is a significant cause of morbidity and mortality in the paediatric population, requiring prompt recognition and intervention. It remains a complex diagnostic problem due to its variable presentation, nonspecific symptoms, and frequently inconclusive imaging findings. A high index of suspicion is essential, particularly in young children presenting with sudden or unexplained respiratory symptoms. Typical assessment of a child presenting with suspected foreign body aspiration includes clinical history and physical examination, followed by chest x-ray. However, chest x-ray results alone have been found to be neither sensitive nor specific enough for the diagnosis of foreign body inhalation. Chest CT has emerged as a valuable tool to aid the diagnostic process, and it is associated with improved sensitivity and specificity. However, its use is limited by the need for sedation and exposure to high doses of radiation. Rigid bronchoscopy remains the definitive modality for both diagnosis and treatment of foreign body aspiration in children. However, flexible bronchoscopy has been established as a safe and effective alternative used for the treatment of foreign body inhalation. Early intervention significantly improves outcomes and reduces complications. In patients with a convincing history and abnormal clinical examination or radiological findings suggestive of foreign body aspiration, bronchoscopy should be performed as soon as possible and feasible. Preventive strategies, including education and policy measures, are essential in reducing the global burden of this condition.

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