Inhaled foreign bodies in children: diagnosis and treatment

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An inhaled foreign body in children is a rare but potentially fatal condition. This article reviews this clinical condition, in particular highlighting the high index of suspicion needed on behalf of the clinicians involved in the care of children. The literature relating to this condition is reviewed and a summary of the clinical course is presented.

An inhaled foreign body in children is a rare but serious problem. About 2000 children die each year in the United States as a result of inhalation or ingestion of a foreign body and 60% of these children are under 4 years of age (Aytac et al, 1977). It represents a potentially fatal condition, and as such it must always be treated as a matter of utmost concern. Prompt diagnosis and appropriate treatment is essential (Anonymous, 1981), as delay in diagnosis is associated with significant morbidity and mortality and represents a major cause of accidental death during childhood (Weissberg and Schwartz, 1987; Humphries et al, 1988).

PATHOPHYSIOLOGY

Mechanisms of obstruction

Four mechanisms of bronchial obstruction caused by inhaled foreign bodies have been described:

1. The check-valve mechanism, by which air is inhaled and cannot be expelled, causing unilateral hyperinflation (emphysema) on the affected side
2. The stop-valve mechanism, caused either by a large foreign body or by a gradually swollen small foreign body, leading to distal atelectasis
3. The ball-valve mechanism, by which a foreign body dislodges during expiration and reimpacts during inspiration, leading to early distal atelectasis on the affected side
4. The bypass-valve mechanism, caused by partial obstruction of the bronchial lumen, resulting in diminished aeration and opacity on the affected side (Chatterji and Chatterji, 1972).

Inhaled agents

Peanuts are the most common inhaled foreign body in European and American literature (Mantel and Butenandt, 1986; Hamilton et al, 1989; Mu et al, 1991; Carluccio and Romeo, 1997; Yeh et al, 1998), and in some series peanuts were the causative agent in up to 65% of cases (Carluccio and Romeo, 1997). However, there is regional variation; for example, in Mediterranean and Arabic countries melon and sunflower seeds often present as inhaled foreign bodies in children (Aytac et al, 1977).

Acute respiratory obstruction caused by accidental swallowing of live fish while swimming (Trevett et al, 1992), and lodgement of live fish in the tracheobronchial tree are extremely rare occurrences, but are potentially fatal (Sarkar, 1993).

In general terms, organic foreign bodies are more dangerous than inorganic matter, as they swell with the bronchial secretions and cause mechanical obstruction. Furthermore, organic matters contain antigenic proteins, organic acids and oil that are absorbed and may lead to severe allergic and chemical bronchitis.

The approach to children with suspected allergic bronchitis secondary to inhaled foreign bodies should include resuscitative measures such as oxygen, bronchodilators, antihistamines, intravenous steroids and possibly adrenaline, as well as attention to the inhaled foreign body.

CHILDREN AT INCREASED RISK

Inhalation of a foreign body is seen more frequently in children under 6 years of age, with a peak incidence between the ages of 1 and 3 years (Aytac et al, 1977; Cotton and Yasuda, 1984; Mantel and Butenandt, 1986; Laks and Barzilay, 1988; Steen and Zimmermann, 1990; Mu et al, 1991; Carluccio and Romeo, 1997; Yeh et al, 1998); in some reports, up to 77% of children affected are between the ages of 1–3 years (Aytac et al, 1977). Children under the age of

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3 years are at the greatest risk, because the major airways are narrow and their protective mechanisms are inadequate.

Peanuts and watermelon seeds pose particular hazards to 1-year-old children, who lack molar teeth; this leads to an inability to chew. Furthermore, younger children have a narrower diameter of the airway, making them more susceptible to obstruction, especially caused by secondary oedema.

On average, boys appear two to three times more vulnerable to inhaled foreign bodies than girls, and thus present to hospital more frequently (Carluccio and Romeo, 1997; Yeh et al, 1998).

CLINICAL FEATURES: SYMPTOMS

Presenting symptoms include the triad of coughing or choking, wheezing and dyspnoea, present in up to 74%, 70% and 51% of cases respectively (Carluccio and Romeo, 1997). This may be followed by fever, which is a late feature and is seen less commonly, in only 20–36% of cases; it results from collapse or consolidation of the distal lung parenchyma. Fever can be present 24–72 hours following inhalation of a foreign body (Laks and Barzilay, 1988; Carluccio and Romeo, 1997). Blood-tinged sputum can also be a sign of an inhaled foreign body.

Common physical signs on initial presentation include decreased breath sounds, tachypnoea and fever in 65%, 43% and 36% of cases respectively (Laks and Barzilay, 1988).

Clinical features of chronic foreign body inhalation include:

- Fever
- Bronchopneumonia that may be recurrent
- Pulmonary abscess
- Bronchopleural fistula, and in severe cases even damage to the affected bronchus
- Bronchiectasis
- Pseudosequestration of a lobe (Scully, 1983; Losek, 1990).

DIAGNOSIS

The most important factor in diagnosis is to always consider the possibility of inhalation of a foreign body in children (Powell, 1965). An accurate and detailed history is absolutely vital in making the diagnosis (Healy, 1990). An episode of choking, coughing, wheezing, persistent cough and temperature in a previously healthy child, who does not respond to adequate treatment, should always raise the suspicion of an inhaled foreign body (Healy, 1990; Sarkar and Gandhi, 1991).

It is important to distinguish between upper airway obstruction, which usually presents with stridor and hoarseness, and lower airway lodgement, which usually presents with an acute cough, possibly with diminished breath sounds.

INVESTIGATIONS

A routine chest radiograph is helpful in either demonstrating the foreign body directly, or showing signs suggesting the lodgement of a foreign body in the airway. Radio-opaque foreign bodies can be easily recognized on plain films taken in posteroanterior or lateral views. However, the chances of detecting a radio-opaque foreign body on a chest radiograph in most reported series is <10% (Aytac et al, 1977; Steen and Zimmermann, 1990; Carluccio and Romeo, 1997; Yeh et al, 1998).

A chest radiograph may detect other abnormalities and changes in up to 80% of cases (Weissberg and Schwartz, 1987; Carluccio and Romeo, 1997), such as:

- Atelectasis
- Signs of consolidation
- Cardiomediastinic shift contralateral to the foreign body
- Air-trapping/emphysematous changes on the same side as the foreign body (Anonymous, 1981; Banerjee et al, 1988; Hamilton et al, 1989; Steen and Zimmermann, 1990; Sarkar and Gandhi, 1991).

Emphysematous changes or air-trapping on the same side as the inhaled foreign body is the most common abnormal feature seen on a chest radiograph. This is caused by the expansile 'check-valve' phenomenon, and occurs in up to 20% of cases (Yeh et al, 1998).

The presence of a pneumomediastinum on plain chest film further raises the possibility of an inhaled foreign body (Burton et al, 1989; Puhakka et al, 1989). If the inhaled foreign body is a sharp object, the possibility of tracheobronchial perforation is high, with the resultant pneumothorax and/or pneumomediastinum.

However, in up to 25% of children with a proven diagnosis of an inhaled foreign body, retrospective review of the initial chest radiograph was found to be normal (Aytac et al, 1977; Humphries et al, 1988; Burton et al, 1989). Therefore, a chest radiograph is neither sufficiently sensitive nor sufficiently specific to have a definitive role in making a diagnosis of an inhaled foreign body (Svedstrom et al, 1989).

Lateral decubitus film may be helpful in young children with limited cooperation (Hamilton et al, 1989; Kamei, 1991). In cases of doubtful diagnosis, perfusion scintigraphy of the

lungs may show areas with no or reduced ventilation as areas corresponding with diminished perfusion (Cotton and Yasuda, 1984; Mantel and Butenandt, 1986).

INITIAL ASSESSMENT AND FIRST AID

An inhaled foreign body is potentially a life-threatening condition in children. Any child with a suspected inhaled foreign body requires urgent attention, which involves a great element of public education and pre-hospital care.

If there is complete obstruction of the airway upon inhalation of a foreign body, and the child is apnoeic and unable to move air in and out of the lungs, then initially either the Heimlich manoeuvre or the 'back-and-chest thrust' manoeuvre is recommended.

If this fails, mouth-to-mouth resuscitation can be attempted; but in the apnoeic child the mouth should also be checked for a foreign body and the airway position should be optimized by lifting the chin and protruding the jaw before commencing mouth-to-mouth resuscitation. Mouth-to-mouth resuscitation is attempted in the hope that the foreign body is dislodged further into either of the main-stem bronchi, thereby enabling sufficient ventilation to one of the lungs during transport to an emergency medical facility. Fortunately, most foreign bodies inhaled by children are small and pass through the trachea, lodging in either of the main-stem bronchi.

Less direct methods such as postural drainage are potentially dangerous as a foreign body initially lodged in the right main bronchus can be freed, only then to lodge in the left main bronchus. Under these circumstances, effective ventilation virtually ceases as the right main bronchus remains oedematous and occluded, while the left airway is now occluded. Another potential problem is laryngeal obstruction caused by the lodging of an object too large to pass freely through the larynx.

Fortunately, by the time most children with a suspected foreign body arrive at hospital they are not in an immediately life-threatening condition, but they do require urgent attention. There is usually sufficient time for full assessment and treatment. Children with suspected inhaled foreign bodies should definitely be admitted to hospital. Sudden dislodgement of the foreign body from the original location may cause complete obstruction of a vital part of the airway, leading to death (Aytac et al, 1977). This complication has been reported following the Heimlich manoeuvre, which is widely recommended and practised as a first-aid measure (Cohen et al, 1980; Banerjee et al, 1988).

DEFINITIVE BRONCHOSCOPIC TREATMENT

Bronchoscopy is the treatment of choice and should be carried out under general anaesthesia with pre-oxygenation (Mantel and Butenandt, 1986). This facilitates easy extraction and minimizes the development of subglottic oedema secondary to operative manipulation and trauma.

The use of corticosteroids is highly recommended in younger children, particularly in those showing inflammatory signs before bronchoscopy, as it reduces the degree of oedema of the bronchial mucosa, facilitates easy removal of the foreign body and prevents subglottic oedema following bronchoscopy (Aytac et al, 1977; Cohen et al, 1980; Pasaoglu et al, 1981; Mantel and Butenandt, 1986; Banerjee et al, 1988; Steen and Zimmermann, 1990).

The bronchoscopy should be performed by an experienced operator, such as an ear, nose and throat surgeon, a thoracic surgeon or an experienced anaesthetist (Anonymous, 1981; Cotton and Yasuda, 1984; Mantel and Butenandt, 1986; Healy, 1990); all should be experts in the management of children's airways in order to prevent several unusual complications that are caused by a lack of experience (Cohen et al, 1980). Who performs the bronchoscopy may vary from unit to unit, but collectively the team undertaking the bronchoscopy should be competent at performing an urgent tracheostomy if required.

The rigid bronchoscope is preferable to the fibreoptic bronchoscope when extracting foreign bodies in children because of the small diameter of the trachea and glottis (Cohen, 1981). A rigid bronchoscope equipped with the Storz-rod lens system is preferred because of superior quality of the optical image (Wood, 1984; Mantel and Butenandt, 1986; Hamilton et al, 1989). Furthermore, the rigid bronchoscope is far more effective in manipulating the foreign bodies, as a wider selection of extraction forceps and suctioning devices can be introduced by the operator (Cohen, 1981; Pasaoglu et al, 1981; Wood, 1984; Banerjee et al, 1988; Healy, 1990; Steen and Zimmermann, 1990).

The Fogarty balloon catheter has been used successfully for the removal of peanuts and other spherical objects (Aytac et al, 1977; Kosloske, 1982; Banerjee et al, 1984; Laks and Barzilay, 1988; Losek, 1990). However, caution must be used as the balloon catheter may break and become a second foreign body beyond the impacted material (Healy, 1990).

The other possibilities for the easy extraction of foreign bodies are the Dormia basket

(Banerjee et al, 1984) and the magnetic probe for iron-containing foreign bodies (Mantel and Butenandt, 1986).

In children in whom the evidence is equivocal or the foreign body has not been seen on previous rigid bronchoscopy, fibreoptic bronchoscopy may be necessary to obtain a complete and thorough examination, especially by visualizing the peripheral bronchial tree (Wood, 1984). An introducing laryngoscope may be useful to exclude the possibility of a foreign body in the larynx, as well as for the purposes of inserting a ventilating bronchoscope (Powell, 1965; Cotton and Yasuda, 1984; Puhakka et al, 1989).

Bronchoscopic findings confirm that the foreign body lodges more frequently in the right bronchial tree, as reported in 71% of cases in a large series (Aytac et al, 1977). The explanation for this includes:

- The straighter course of the main right bronchi
- Deviation of the trachea to the right
- The preference of infants to lie on one side.

It should be noted that in a significant proportion of cases (10%), the foreign body lies in the trachea close to the bifurcation, which is a particularly hazardous situation. Bilateral localization of foreign bodies can occur, but it is rare (<1%) (Aytac et al, 1977).

There are particular problems associated with the retrieval of long-standing inhaled foreign bodies in children. These include the peripheral location of the inhaled foreign body and the presence of granulation tissue (Barbato et al, 1996). Often the foreign body has been pushed further down at previous attempted removals. During the removal of granulation tissue to free the foreign body, a few doses (usually two to four) of an aqueous solution of topical adrenaline 1:100 000, at a dose of 0.1 ml/kg body weight, administered intrabronchially is extremely useful to achieve haemostasis (Barbato et al, 1996).

In children where there is a clear history of aspiration of a vegetable or nutty substance, repeated bronchoscopic examination must be anticipated. Residual foreign bodies have been discovered in up to 20% of these children following the initial bronchoscopic examination.

An ideal bronchoscopic manipulation should not last longer than 30 minutes (Aytac et al, 1977; Pasaoglu et al, 1981). Bronchoscopy is not without its associated risks. Death caused by a severe hypoxic episode and cardiac arrest during and after the procedure has been reported, although this is rare (<2% of cases) (Aytac et al, 1977; Pasaoglu et al, 1981; Banerjee et al, 1988). Spontaneous expectoration of foreign bodies occurs in only 1–2% of cases (Aytac et al, 1977).

Endoscopic removal of the foreign body may not be successful in some cases, particularly with spherical objects such as beads. If all endeavours to remove the foreign body by endoscopic means fail, then surgical removal by thoracotomy and bronchotomy is necessary. However, the surgeon must bear in mind that there is a well-documented incidence of the bead shifting to the contralateral hemithorax during thoracotomy (Aytac et al, 1977). This rare but difficult situation can be prevented by keeping the patient in a 'head-up, feet-down' position, and isolating the affected bronchus with an endotracheal tube.

COMPLICATION OF A CHRONICALLY INHALED FOREIGN BODY

Elimination has been reported to occur rarely through a spontaneous pneumocutaneous fistula, and is unique to inhaled influorescent agents (grass spikelets and hair bristles) (Choremis et al, 1964; Naylor, 1966; Cavens et al, 1973). Delayed diagnosis may lead to recurrent pneumonia, bronchiectasis, lung abscess, bronchopleural fistula (Losek, 1990), pseudosequestration of the lobe of lung (Scully, 1983) and even death when chronic symptoms are absent (Humphries et al, 1988). In situations where a late sequalae of inhaled foreign body is noted, bronchoscopic removal may be difficult and hazardous, and it may be necessary to undertake thoracotomy, bronchotomy and segmental or lobe resection (Powell, 1965; Anonymous, 1981; Scully, 1983; Banerjee et al, 1988; Laks and Barzilay, 1988; Puhakka et al, 1989).

PREVENTION AND EDUCATION

The often-quoted adage that prevention is better than cure most certainly applies to an inhaled foreign body in children. Many incidences of foreign body aspiration can be prevented by educating and informing parents of young children, particularly children below the age of 3 years. The dangers of nuts in younger children cannot be overemphasized. Furthermore, children's nurseries and playgroups need to be aware of the risks associated with food choking (Steen and Zimmermann, 1990).

A nationwide education campaign conducted on television, radio broadcasts, newspaper articles and medical education programmes in community paediatric care centres has been reported to be effective. In a report from Israel, within

2 years of initiating such a programme from 1981–83, there was a 35% reduction in the incidence of aspiration of foreign bodies in children; however, there was a plateauing effect with no further reductions noted when reassessed 10 years later in 1991 (Sadan et al, 1995).

Strategies need to evolve further for mandatory legislation of product modification to eliminate unsafe characteristics and to promote labels on the product with information about the age groups particularly at risk (Harris et al, 1984; Sadan et al, 1995).

CONCLUSION

Any child with a suspected foreign body needs urgent medical attention. Clinical signs and findings on examination may often be subtle, and therefore a high degree of suspicion is needed. Rigid bronchoscopy remains the gold standard for thorough examination of the airway and for removal of the foreign body. A greater awareness by the public of the risk of inhaled foreign bodies in children is likely to reduce the numbers of children presenting with this potentially fatal clinical scenario. HM

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KEY POINTS

- Inhalation of a foreign body in children is a potentially fatal condition.
- Children suspected of inhaling a foreign body need urgent medical attention.
- A high index of suspicion is needed as examination and investigations, such as chest X-ray, may be unremarkable.
- Rigid bronchoscopy remains the definitive diagnostic and therapeutic tool, and should be undertaken by experienced operators.
- More extensive surgery is usually only needed for chronic cases with complications from an inhaled foreign body.
- Public awareness and education is an important step towards prevention.

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