

INHALED FOREIGN BODY IN CHILDREN ANAESTHESIA TUTORIAL OF THE WEEK 99

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Before reading the tutorial, consider this case scenario and answer the following questions (answers & discussion follow):

Case History

A 17 month old male infant weighing 13.5 kg presents to the Accident and Emergency department with shortness of breath.

He had been eating three hours previously and his mother gave a history of a sudden bout of coughing. On arrival in the emergency department, he was distressed, crying and coughing intermittently. He had no stridor, however his respiratory rate was 40 breaths per minute with some intercostal and sternal recession. Auscultation revealed a mild wheeze worse on the right side of the chest. Saturations were 94% on air.

A plain Anterior-Posterior chest X-ray was clear with no evidence of pneumothorax, collapse, consolidation or hyperinflated areas.

Questions (answer “True” or “False”):

- Most aspirated foreign bodies will be lodged in one of the main bronchi.
- Anaesthesia must be delayed until the child is adequately fasted.
- Most aspirated foreign bodies in children will be visible on plain chest x-ray film.
- The child may need a chest x-ray in inspiration and expiration to help the diagnosis.
- Anaesthesia for rigid bronchoscopic removal of foreign body is urgently indicated in this child.
- Steroids may be given to prevent inflammation of the airway.

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- A sedating premedication such as oral midazolam must be prescribed to reduce anxiety.
- IV atropine may be considered to prevent halothane induced bradycardia.
- Inhalational anaesthesia with oxygen, N₂O and either halothane or sevoflurane is the induction of choice.
- 2.5 mls of 4% Lignocaine to the vocal cords would be a suitable local anesthetic preparation before rigid bronchoscopy.
- If the child develops complete airway obstruction in the emergency department, the child should be immediately anaesthetised for bronchoscopic foreign body removal.
- The airway is secure and safe once the rigid bronchoscope has passed through the vocal cords.

Aetiology, Incidence and Prognosis.

Foreign body (FB) aspiration is one of the leading causes of death young children; for example, FB aspiration has been responsible for more than 300 deaths per year in the USA (Black RE *et al.* 1994). It most commonly occurs in the 1-3 year-old age group, tending to occur in boys more than girls. Children of this age are prone to foreign body aspiration because they:

- Put objects in their mouths (particularly while running)
- Have less ability to chew food in the absence of molar teeth (Weir PM 2004)

Most deaths occur at the time of aspiration due to complete upper airway obstruction. Of those children who reach hospital, the mortality is low; in fact, in many large case series in the 1990s, the in-hospital mortality has been reported as zero (Farrell PT 2004). Despite this, significant peri-operative morbidity and mortality can still occur and can potentially be reduced, prevented or anticipated with appropriate management and precautions.

The most common aspirated object is 'food', with nuts being the most common within this category. Peanuts account for one third of all FB aspirations (Wong SW 1999).

Presentation and diagnosis

The diagnosis of FB aspiration can be difficult; frequently the inhalation event is not witnessed, and the history may be less clear than expected. Moreover, younger children are 'pre-verbal', and are unable to say what has occurred. The presentation is variable, and dependent on:

Early versus late presentation

Size and shape of object inhaled

Site of object within the airway (trachea/main bronchus/distal airways)

Time of presentation since event

The early presentation can therefore range from severe acute upper airway obstruction through to a well, pink child often with a cough. The children presenting late often present with signs of secondary lower respiratory tract infection. More than 90% of FBs lodge in a main bronchus – occurring only slightly more commonly on the right side in children.

The diagnosis is therefore based on the degree or 'index of suspicion'. In turn, this is based on a careful history, examination and special investigations.

History: a classical history may comprise a sudden onset of choking, followed by coughing and wheezing. A history of choking has been shown to have a sensitivity of 81% and specificity of 33% (Hoeve LJ *et al.* 1993); this in itself should lead to a high index of suspicion of inhaled FB. The type of object can give useful information as to the likely size and therefore site of lodgement, as well as the likelihood of visibility on Chest X-ray. Some objects such as batteries, will have a higher degree of urgency due to their corrosive nature. There may be a history of a persistent cough.

Examination: Signs such as cyanosis, stridor, severe intercostal/sternal recession or evidence of reduced conscious level are consistent with upper airway obstruction requiring emergency management (see later section). A history of voice change or barking cough may indicate laryngeal oedema or upper airway foreign body obstruction (Farrell PT 2004). A persistent cough has been shown to have a

sensitivity of 78% and specificity of 37%. Similarly, abnormal findings on auscultation had a sensitivity of 78% and specificity of 50% (Hoeve LJ *et al.* 1993). A late presentation may well include signs of pneumonia, such as fever, cough, tachycardia, tachypnoea and focal chest signs.

It must be remembered that none of the features above are 100% specific, and the differential diagnoses must be considered such as asthma, pneumothorax, croup or other infective respiratory tract infections.

Special investigations: Apart from oxygen saturations, most cases will have an Antero-posterior Chest X-ray and Lateral Chest X-ray. The films should extend to the entire neck (Rovin JD & Rogers BM 2000). It must be remembered majority of inhaled material is organic in origin, and therefore a plain radiograph may fail to demonstrate an abnormality – especially in the first 24 hours; the absence of radiographic abnormalities does not therefore exclude the diagnosis of an inhaled FB. The sensitivity of the plain radiograph as a diagnostic tool in these patients has been cited at only 67-82%, with a specificity of 44-74% (Farrell PT 2004). Of note, another study found the rate of **normal** chest X-ray findings in children with known FB to be 56% if tested in the first 24 hours after inhalation, but only 33% were normal if more than 24 hours had passed (Mu L *et al.* 1993).

To improve the sensitivity, fluoroscopy or plain X-rays in inspiration and expiration have been suggested, particularly for those with a normal plain chest x-ray and a high index of suspicion of FB (Weir PM 2004). Evidence of gas trapping may be seen.

The most frequent radiological findings seen in FB aspiration are (Adapted from Rovin JD & Rodgers BM 2000):

- Normal – no abnormality
- Gas Trapping (due to ball-valve effect of foreign body with respiration)
- Mediastinal shift
- Atelectasis
- Lobar collapse/consolidation

Management strategy

a) Immediate Basic Life Support Management.

If the child is acutely unwell, they should initially be assessed and managed as per the ‘choking child’ Basic Life Support Algorithm.

This involves **2 questions** in the assessment process:

1) Does the child have an effective cough? (ie crying, talking, can take a breath between coughs, cerebrating, not cyanosed etc) If so, they should be closely observed and encouraged to cough by themselves. Physiotherapy or interventions such as back blows or chest/abdominal thrust in this situation are not only less effective than the child’s own efforts, but run the risk of dislodging the FB and *worsening* the obstruction.

If the cough not effective, the next question is:

2) Is the child conscious?

If the child is conscious, the rescuer may intervene with 5 back blows followed by 5 chest thrusts (abdominal thrusts may be used in older children (older than infants)).

If the child is not conscious, the child should have airway, breathing and circulation assessed and managed as per the basic life support guidelines, with assisted ventilation and chest compressions. These guidelines can be found at: http://www.alsg.org/fileadmin/_temp_/Specific/Ch04_BLS.pdf

b) Subsequent management strategy

Most children who reach hospital with an inhaled FB will have an effective cough. Once the child has been assessed (above), arrangements need to be made for transfer to theatre with appropriately skilled senior personnel for a bronchoscopy under general anaesthesia. Depending on the degree of certainty of the diagnosis, clinical state of the child, operator familiarity and local protocol, this could involve the initial use of either a flexible or rigid bronchoscope in order to confirm the diagnosis.

Traditionally, the ‘gold standard’ management is for an ENT or paediatric surgeon to use a rigid open tube bronchoscope, which is then most commonly used for FB removal. In most centres, this is the technique of choice for FB investigation and removal, however reports are published on the successful use of the flexible bronchoscope as not only a diagnostic tool, but as a means of FB removal using ureteral stone baskets and forceps (eg Mayo Clinic, Rochester, USA). These authors still emphasize that a rigid open tube bronchoscope should still be immediately available should problems occur (Swanson *KL et al.* 2002).

Overall, however, at present it remains common practice to use the rigid bronchoscope for foreign body removal, in view of:

- The widespread availability of FB removing equipment that fits down the lumen of the bronchoscope.
- Operator Familiarity
- Ease of delivering oxygen and anaesthetic gasses into the sidearm of the rigid bronchoscope.

The key to success is communication between all medical staff with regard to planning and equipment. The anaesthetist should be familiar with all initial and contingency plans, and should also have checked the bronchoscope and that it connects to the breathing system. Experienced senior medical staff should perform the procedure in a fully equipped procedure room; ‘junior staff’ (particularly the proceduralist) have been identified as a risk factor for intra-operative complications, such as dropping the FB during extraction while negotiating the vocal cords (Pawar *DK* 2000). It is also suggested that two anaesthetists should be present – one of whom should be a paediatric anaesthetist (Farrell *PT* 2004).

Technique of Anaesthesia

a) Preparation

Once the assessment has been made and the personnel in place, a number of considerations need to be made before theatre:

i) Fasting

Ideally, children should be fasted for at least 6 hours for solids and 2 hours for clear fluids to reduce the probability and severity of aspiration under anaesthesia. As in the scenario above, a compromise sometimes has to be made, in view of the urgency of the case. Depending on the clinical state of the child, children are often transferred to theatre without full ‘ideal’ fasting. Many clinicians would still advocate an inhalational induction with spontaneous breathing despite a potential full stomach (Weir *PM* 2004).

ii) Premedication

Careful clinical judgement needs to be exercised with regard to sedative premedication. If possible, the child should be kept calm up to the moment of induction, to avoid dislodgement and worsening of the obstruction. However, many clinicians often avoid sedative premedication to improve perioperative respiratory drive.

Anticholinergic premedication may be of use to reduce the bradycardia of halothane, vagal-induced bradycardia, blockade of reflex bronchoconstriction and reduce airway secretions (Tan *HKK & Tan SS* 2000); however, its routine use has been questioned and many avoid using atropine or glycopyrrolate in some surveys (Parnis *SJ* 1994).

iii) Medical therapy

Although pre-operative chest physiotherapy has been used in the past, it may dislodge the FB more proximally and worsen the airway obstruction (Farrell PT 2004). This is therefore not performed.

Antibiotics may be given to those presenting late with clinical features of pneumonia. Steroids are also often employed to treat and prevent laryngeal oedema, although there is little documented evidence for its efficacy (Weir PM 2004).

iv) Intravenous access

Despite the potential full stomach, it may be reasonable to insert the cannula in the distressed child with difficult veins once the child is induced with anaesthetic. Sensible clinical judgment needs to be employed.

b) Induction of Anaesthesia

Most anaesthetists will use an inhalational induction with either sevoflurane or halothane in order to maintain spontaneous ventilation.

Although Halothane is cheap, smooth at induction and easy to maintain depth with spontaneous ventilation, its lack of familiarity amongst many anaesthetists and propensity for cardiac dysrhythmias renders it less popular than in previous years.

Many now favour sevoflurane, with the advantage of relative stability of the cardiovascular system. Furthermore, a study comparing the two agents (with N₂O) in children undergoing bronchoscopy and gastroscopy demonstrated the sevoflurane group had faster recovery and less post-operative nausea and vomiting compared to the (Meretoja OA et al. 1996).

N₂O is usually avoided for induction and maintenance, particularly if there is radiological evidence of gas trapping. It is also advisable to be able to preoxygenate with anaesthetic agent/O₂ mix before instrumentation by the proceduralist.

Once at adequate depth (using eye signs, respiration pattern and abdominal wall tone), the cords and upper trachea are sprayed under direct laryngoscopy with 4mg/kg lignocaine (lidocaine). This reduces the cardiovascular and tussive response to bronchoscopy.

c) Maintenance of Anaesthesia

This is challenging for the anaesthetist – especially in the presence of reduced gas exchange in many of these children. Considerable controversy exists as to how to conduct ventilation and oxygenation during rigid bronchoscopy in children. Traditionally, it is felt that a spontaneously breathing technique is superior, as it reduces the chance of distal movement or dislodgement of the FB, and may be less likely to worsen distal air-trapping.

Frequently an Ayre's T-piece (Mapleson F) is connected to the sidearm of the Storz bronchoscope, allowing volatile maintenance of anaesthesia, oxygenation and ventilation. A second reason cited for spontaneous ventilation, is that when the bronchoscope is passed more distally, oxygen and volatile is delivered to a smaller proportion of the lung; in the spontaneously breathing child, oxygen enriched gas is entrained from around the bronchoscope, so improving oxygenation.

An alternative method is to paralyze the patient and use positive pressure ventilation. A randomized controlled trial has suggested this technique is superior to the spontaneous ventilation technique, in terms of number and severity of coughing and desaturation episodes. It may be that there is reduced atelectasis with positive pressure ventilation, and it overcomes the resistance to breathing through the bronchoscope. The authors suggested that the risk of FB dislodgement with positive pressure ventilation may be overstated (Soodan A *et al.* 2004). The conclusions were controversial as some felt that a spontaneous ventilation technique is more reliable with the addition of intravenous anaesthetic agents and/or low dose opiates such as remifentanyl (Buu NT & Ansermino M 2005). Many other studies have been cited, however the good outcomes associated with this procedure has made it difficult to demonstrate the superiority of one technique over another (Farrell PT 2004).

d) Perioperative complications of anaesthesia for FB removal.

There are many uncommon potential complications of FB removal:

Airway

Laryngeal Oedema (secondary to FB or instrumentation)

Complete airway obstruction (secondary to dislodged FB during coughing or removal)

Failure to remove object

Breathing

Hypoxia

Hypercarbia

Coughing

Regurgitation and aspiration of gastric contents

Pneumothorax

Pneumonia

Circulation

Cardiac Dysrhythmias

Cardiac Arrest

Neurological

Fits (secondary to hypoxia/hypercarbia)

Other

Death

It is worth reminding the reader that a common time for a serious complication is during removal of the FB. The FB may become snagged and dislodged at the cords/larynx, causing severe or complete airway obstruction. Due to bronchial oedema of the affected side, the object may fall into the 'good' lung, so compromising gas exchange. If the object becomes lodged in the trachea, the FB needs to be retrieved rapidly. If this is not possible and severe desaturation occurs, the FB may need to be pushed down one bronchus to allow some gas exchange.

Occasionally an emergency tracheostomy may be required and preparation should be made for this before the start of the case.

Post Operative Care

This depends on the clinical state of the child; however a chest X-ray should be performed to exclude a pneumothorax or further abnormality. If clinically well, children can often be discharged on the same day of surgery. Consequences of delayed treatment may need to be treated such as pneumonia.

Summary

- Inhaled FB is an important cause of death in infants. Preventative measures e.g. toy safety, supervision are vital to reducing these deaths.
- A high index of clinical suspicion is required in those without obvious diagnosis.
- Expertise of personnel, clear clinical plans and familiarity with equipment is the key to success.
- Although controversial, a spontaneous breathing technique with intravenous opioid/anaesthetic agent supplementation is most commonly employed.
- Removal of the FB can be a dangerous part of the procedure, and can precipitate complete obstruction.

Answers to Questions

- True

90% of inhaled foreign bodies will be lodged in one of the bronchi – even in children more than 50% will be on the right side.

- False

This is an emergency with respiratory compromise. The child is breathing and effectively coughing of his own accord – there is no need to intervene with back slaps or abdominal/chest thrusts (see APLS guideline algorithm above); this would risk trauma and dislodging the body into the trachea causing complete obstruction. It would also cause further distress.

- False

Most aspirated foreign bodies are not visible on plain chest X-ray. It would also be unusual to see consolidation changes on the X-ray in the early stages after the event.

- False

Although inspiratory and expiratory films (plain or using fluoroscopy) may help the diagnosis, the child is suffering from respiratory distress on the background of a good history of sudden onset of coughing. Most clinicians in this situation will wish to perform a bronchoscopic removal of foreign body under anaesthesia urgently.

- True

See above (answer 4).

- True

Although very little evidence of its efficacy, many would consider a single dose of steroids to reduce post operative upper airway obstruction.

- False

Although a premedication may be considered, other techniques such as parental presence is often useful as a substitute. A sedating premedication may make a spontaneously breathing technique more difficult under anaesthesia.

- True

Although it is frequently not used in some countries where sevoflurane is the drug of choice.

- False

Nitrous Oxide should be avoided to avoid worsening any gas trapping and allow better pre-oxygenation before instrumentation.

- False

2.5mls of 4% lignocaine is 100mg. This is way above the recommended dose of approximately 4mg/kg, and may cause toxic effects due to mucosal absorption.

- False

Complete airway obstruction requires the basic life support choking child algorithm

See European Resuscitation council guidelines Biarent *et al.* 2005 or APLS manual -

http://www.alsg.org/fileadmin/_temp_/Specific/Ch04_BLS.pdf

- False

See list of perioperative complications above. The FB may be dropped when passing through the larynx.

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