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Rigid bronchoscopy for foreign body removal: anaesthesia and ventilation

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Summary

Foreign body aspiration is a leading cause of death in children 1–3 years old, although mortality is low for children who reach the hospital. Presenting symptoms of an inhaled foreign body depends on time since aspiration. Immediately after inhalation the child starts to cough, wheeze, or have laboured breathing. If the early signs are missed, the child usually presents with fever and other signs and symptoms of chest infection. A plain chest X-ray has relatively low sensitivity and specificity for inhaled foreign body. The gold standard for diagnosis and management of this condition is rigid open tube bronchoscopy under general anaesthesia. For late presentations, time should be taken to fast the child and complete a thorough evaluation before bronchoscopy. The procedure should be performed in a well-equipped room with at least two anaesthesiologists, one with paediatric experience, in attendance. Most experienced anaesthesiologists prefer inhalational rather than intravenous induction of anaesthesia and a ventilating bronchoscope rather than intubation. Equally good results have been reported with spontaneous ventilation or positive pressure ventilation; jet ventilation is not advocated for foreign body removal in children.

Keywords: foreign body aspiration; rigid bronchoscopy; ventilation; young children

Introduction

Different authors advocate different ventilation techniques for bronchoscopy. This is highlighted by the following quotes from two different textbooks:

> '… topical anaesthesia of the airway and spontaneous respiration using a volatile agent in oxygen is usually satisfactory' (1)

> 'Spontaneous breathing with any potent inhalational anaesthetic does not provide adequate gas exchange … therefore … current indications or applications for spontaneous breathing during rigid bronchoscopy are limited…' (2)

Is there a best technique for ventilation during bronchoscopy, or is the ventilation technique a relatively insignificant factor in the outcome of the

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procedure? To start to answer this question we need to review the clinical problem.

The clinical problem

Foreign body aspiration occurs most commonly in infants between 1 and 3 years old, with a peak incidence in the second year of life (3–5). The list of objects inhaled is long. However, 'food' is the commonest category of items aspirated, and nuts, especially peanuts, are the commonest type of food inhaled (3–5).

Foreign body aspiration is a leading cause of mortality in children 1–3 years old (6), and most deaths occur at the time of aspiration. In most series, the mortality is zero for patients who reach the hospital alive (3,4,6).

Where the foreign body lodges in the airways depends on its size and shape. In many series of children, foreign bodies were as likely to be found in the left as in the right lung (3,7). Some foreign bodies lodge in the trachea, but the majority are found in the proximal airways. Small, sharp objects can lodge in the subglottic area, where they can be difficult to diagnose (8).

Diagnosis

The child with a foreign body in the airway usually presents with a history of a choking episode, the aptly named 'penetration syndrome' (3,9). Unless the episode was witnessed, however, it may not be identified if the child is preverbal or a poor historian. Also, the initial symptoms of inhaled foreign body (coughing, wheezing, or raspy breathing) may be missed in these cases.

Late presentation

Fever and the symptoms and signs of a chest infection are typical presenting symptoms in those who are first seen more than 24 h after aspiration (9,10), representing between one-third and one-half of cases (9–11). This means that if there is no acute obstruction, then the situation is unlikely to be life threatening. Thus there is usually time to fast the child, perform chest X-ray and, if necessary, to arrange referral and management by a specialty team (6,12). Late diagnosis is associated with a higher complication rate (6).

Physical examination

Clinical examination of the child with a foreign body in the airway may reveal diminished breath sounds and rhonchi on the affected side. A number of reviews have looked at the sensitivity and specificity of signs and symptoms in foreign body aspiration. A study reported by Hoeve *et al*. gave fairly typical results: a history of a choking episode had a sensitivity of 81% and specificity of 33% for inhaled foreign body, and coughing and abnormal findings on auscultation both had a sensitivity of 78% and specificities of 37 and 50%, respectively, for this condition (9).

Martinot *et al*. reviewed the signs of foreign body aspiration and found unilaterally decreased breath sounds to have a specificity of 88% and a sensitivity of 65% for this condition (13).

Imaging

A plain chest X-ray may rarely show an inhaled foreign body – such images have a sensitivity between 67 and 82% and a specificity between 44 and 74% for foreign body in the airway (4,9,11,13). On the other hand, a foreign body may be suspected by comparing inspiratory and expiratory films that may reveal an area of hyperinflation because of gas trapping and/or mediastinal shift.

Management

The gold standard for managing foreign body aspiration is removal via rigid open tube bronchoscopy. The procedure is performed under general anaesthesia, although anaesthesia may not be needed if the patient is moribund.

Medical management by bronchodilators, pulmonary drainage and thoracic percussion, particularly of peripherally located foreign bodies, has been used (14).

Recently Martinot *et al*. suggested an algorithm for managing suspected foreign body aspiration that evaluates risk of foreign body based on the patient's history, presence of diminished breath sounds and findings on chest X-ray. The algorithm recommends initial flexible bronchoscopy for those at lower risk of foreign body and rigid bronchoscopy for those found to have a foreign body or

whose symptoms suggest a higher risk of foreign body (13).

Protocol for rigid bronchoscopy

The following protocol may be used for rigid bronchoscopic management of an inhaled foreign body.

Preparations for bronchoscopy

Preparations for bronchoscopy may be modified depending on the urgency of the procedure.

Prebronchoscopic assessment
An assessment must be made of the location, suspected type and degree to which the foreign body is obstructing the airway (7) because these factors influence the approach for removal and thus the anaesthesia technique. Distal foreign bodies are more difficult to remove, whereas proximal ones are more likely to obstruct the airway. Signs of airway obstruction include obvious distress, stridor, tachypnoea, and lung retraction. Voice changes, loss of voice, or a barking cough may indicate laryngeal oedema or obstruction, perhaps by the foreign body. Some organic foreign bodies swell; these and larger nonorganic foreign bodies may need to be broken up and taken out in pieces.

Fasting
When an aspirated foreign body causes no or minimal distal airway obstruction, time should be taken to fast and complete other preparations for bronchoscopy (6). Optimal fasting times are 4–6 h for solids and 2 h for clear fluids (15). Fasting is important to decrease the risk of further aspiration because the airway cannot be fully protected during the procedure.

Chest physiotherapy
Chest physiotherapy has been advocated particularly for those with a late presentation where pneumonia was the initial diagnosis. However, this procedure poses a risk of dislodging the foreign body to a more proximal location and completely obstructing the airway (16). It is not generally recommended before bronchoscopy.

Pharmacotherapy
Antibiotic and steroid medications are indicated to treat infection and laryngeal oedema, particularly in the child presenting late.

Setting and personnel
Rigid bronchoscopy should only be undertaken by experienced staff in an operating or procedure room fully equipped for managing paediatric airway emergencies (17). A minimum of two anaesthetists is critical to a successful outcome, and at least one of the anaesthetists should be a paediatric anaesthetist if the patient is an infant (less than 12 months old) (18). Lack of experience was recently cited as a contributing factor to poor outcome of bronchoscopy (19).

Intravenous access
In most situations, there is time for topical anaesthesia to be administered before introduction of the intravenous (IV) catheter, followed by induction of anaesthesia. However, in an emergency situation or with a distressed infant, establishing IV access immediately after inhalation induction is acceptable.

Anticholinergic agents
Anticholinergic agents are often recommended for rigid bronchoscopy; however, their routine use has been questioned (20). In a survey of Australian anaesthetists, very few used anticholinergic drugs routinely (21). In a study comparing three groups of patients undergoing laryngoscopy and bronchoscopy, those in the placebo group had a lower incidence of cardiac arrhythmia compared with those in the atropine group or the glycopyrrolate group (22).

Monitoring
The child undergoing rigid bronchoscopy is monitored the same as for any other procedure under general anaesthesia. Particular attention should be paid to pulse oximetry readings, which will show desaturation before a change in skin colour. In addition, the rate of change in saturation serves as a guide to how well the patient might tolerate an apnoeic episode. Gas analysis gives an unreliable estimate of endtidal CO_2, because most expired gas exits via or around the scope rather than the side arm. Impedance pneumography will indicate

chest wall movement and can be helpful in this situation.

Induction of anaesthesia for bronchoscopy

Induction of anaesthesia by the inhalation or IV route, for rigid bronchoscopy in children with inhaled foreign body, are both described in the literature. The choice is often based on the institution's protocol and the anaesthetist's training. However, spontaneous ventilation must be maintained until it is certain that the child can still be ventilated under anaesthesia (1). Rapid-sequence IV induction is more likely to risk loss of the airway.

Inhalation induction has been thought to pose greater risk of aspiration compared with IV induction, but the results of paediatric anaesthesia outcome studies suggest that the risk of aspiration is greater with intravenous induction (23,24). These studies further suggest that the risk of aspirating gastric contents is small with either induction technique and that if aspiration does occur, the consequences are relatively mild (23,24). Furthermore, a survey of members of the Society for Pediatric Anesthesia found that most anaesthesiologists prefer mask induction without cricoid pressure for a child with an aspirated foreign body and that the more experienced the anaesthesiologists, the more likely they were to choose an inhalational induction (25).

Sevoflurane for many, has become the drug of choice for inhalation induction. A study by Meretoja *et al*. found that sevoflurane was associated with significantly lower incidences of clinically important side effects compared with halothane when used for anaesthesia for bronchoscopy and gastroscopy in infants and children (26).

Topical anaesthesia of the vocal cords and trachea is used as an adjunct to general anaesthesia. Lidocaine 1% has two advantages for this application: (1) larger volumes can be used and (2) it has a short (10-min) duration of action. Doses up to 4 $mg \cdot kg^{-1}$ have been used without complications but the dose may need to be reduced in patients younger than 2 years old and in those with dry mucosa (27).

Choice of bronchoscope

We recommend the Storz type ventilating bronchoscope for rigid bronchoscopy in children with aspirated foreign body because this bronchoscope provides both an airway and a means of visualizing the airway. These widely used instruments come in a range of sizes, from internal diameters of 2.5–6.0 mm; the external diameter of each instrument is about 2 mm larger. When the glass ocular piece is placed over the ventilating bronchoscope, it becomes a steel endotracheal tube.

The great advantage of placing the Storz type bronchoscope without prior intubation is that the trachea is entered under continuous vision. This allows a subglottic or high tracheal foreign body to be seen and reduces the risk of sudden obstruction from dislodging it. An endotracheal tube is not always necessary when this instrument is used, but an appropriately sized tube needs to be immediately available.

The Hopkins rod telescopes allow excellent visualization of the airway and, with the addition of a video camera, allow others in addition to the bronchoscopist to see what is occurring. The telescope does, however, significantly decrease the lumen of the bronchoscope, so the telescope must only be used for short periods to allow for adequate ventilation.

Choice of spontaneous or controlled ventilation

Reports of case series of aspirated foreign bodies rarely comment on the specific anaesthetic technique(s) used during removal beyond noting that the foreign bodies were removed under 'general anaesthesia'. As Inglis and Wagner noted, this lack of detail makes it difficult to compare the outcomes associated with different techniques of anaesthetic administration and monitoring (6). These authors did note that 98% of the bronchoscopies in their study were performed with the child under inhalational halothane anaesthesia and only 2% were performed using a relaxant technique.

On the other hand, some papers are very specific about the technique used. Cohen *et al*., for example, strongly recommend that once it is established that ventilation is possible, a relaxant technique based on suxamethonium be used (7). Metranglo *et al*. report the use of intravenous anaesthesia and controlled ventilation as their technique of choice (11). As the outcomes are almost universally good and there are

no outcome data to support the superiority of either mode of ventilation, how can we decide between spontaneous or positive pressure ventilation?

Advantages and disadvantages of spontaneous ventilation
The arguments in favour of spontaneous ventilation include the lower risk compared with positive pressure ventilation that the foreign body may move more distally, which would increase the difficulty of removal and possibly lead to ball-valve obstruction of the airway. In addition, spontaneous ventilation allows for continued ventilation during removal of the foreign body and rapid assessment of the adequacy of the airway after removal of the foreign body.

A disadvantage of spontaneous ventilation is that the depth of anaesthesia required to permit the insertion of instruments into the airway decreases both cardiac output and ventilation. In addition, the increased resistance to ventilation during the use of the telescope or forceps worsens the hypoventilation.

Advantages and disadvantages of positive-pressure ventilation
One advantage of using a muscle-relaxant technique is that the airway is immobilized, which facilitates removal of the foreign body. A muscle-relaxant technique also allows the use of balanced anaesthesia, which in turn decreases anaesthetic effects on cardiac output. In addition, positive-pressure ventilation may decrease atelectasis, improve oxygenation and overcome the increased airway resistance that occurs when a telescope is used.

A recent review from Rochester, New York, evaluated the incidence of adverse events associated with anaesthesia for foreign body removal. The only difference in outcomes between anaesthetic techniques that allowed for spontaneous ventilation and those that did not was that in some cases in which spontaneous breathing techniques were used initially, the switch was made during the procedure to positive pressure ventilation (28).

Jet ventilation has been reported for removal of foreign bodies in adults (29,30) but it is not widely advocated for use in children. This may be due to less experience with this technique or concern that jet ventilation is more likely to dislodge the foreign body or cause barotrauma.

The dropped foreign body

One of the most serious complications of attempts to remove a foreign body is obstruction of the airway caused by movement of the foreign body. This may occur if the foreign body is dropped or it fragments proximally. Management by the endoscopist includes pushing the foreign body more distally into one of the main bronchi. In a recent case report, Pawar commented that the type of ventilation has less effect on the incidence of this complication than the skill of the endoscopist and the equipment used (19).

Discharge and recovery

In most cases of uncomplicated foreign body removal, the patient can be discharged the same day. A longer hospital stay may be required, however, if there were complications or to treat infection in a patient presenting late after inhaling a foreign body (4,12).

Conclusions

There is no strong evidence for choosing one approach to general anaesthesia over another for bronchoscopy for inhaled foreign body. What the literature does show is that there should be almost no mortality and minimal morbidity when foreign bodies are removed by an experienced endoscopic team and that if the airway is not acutely compromised, then the risk of suffocation is low. Thus it is recommended that these children are cared for by the most skilled team available, which usually means referral to a paediatric centre. In addition, taking time to fast the child and complete thorough evaluations before the procedure are key elements for successful management of this problem.

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