Inhaled Foreign Bodies in Children - Anaesthetic Considerations

H K K Tan, S S Tan

ABSTRACT

Many anaesthetic problems and hazards exist in children with inhaled foreign bodies. Careful, stepwise and detailed consideration of clinical history, examination and investigations cannot be over-emphasised. Special consideration has to be given to the fragile paediatric cardiopulmonary status especially in the presence of airway foreign body. The small paediatric airway is frequently shared for anaesthesia and endoscopy. Complete cooperation and good communication between the endoscopist and the anaesthetist is paramount in achieving an optimal outcome.

Keywords: Aspiration, Paediatric, Endoscopy, Anaesthesia, Complications

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INTRODUCTION

The presence of a foreign body in the tracheo-bronchial tree creates unique challenges in airway management. Most reports from both large and small series of foreign body removal from paediatric airways include at least one fatality[1,2,3]. Avoidance of hazards demands the optimum in skills, as well as close cooperation between the endoscopist and anaesthetist.

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PATHOPHYSIOLOGY

The effects of foreign body aspiration are dependent on the site of lodgement, degree and duration of obstruction. Upper airway involvement varies from complete obstruction with hypoxia and cardio-respiratory compromise to partial obstruction with coughing, wheezing, drooling, stridor and respiratory distress.

Foreign bodies located in the lower airway lead to pulmonary changes dependent on the type of impaction. Chatterji and Chatterji (1972)[4] described four types: check valve; in which air can be inhaled but not exhaled resulting in emphysema, ball valve; in which air can be exhaled but not inhaled giving rise to collapse of the bronchopulmonary segment, by-pass valve; whereby the foreign body partially obstructs both inspiration and expiration, and stop valve; where there is total blockage causing airway collapse and consolidation.

Special consideration must be given to children in whom limited functional residual capacity leads to reduced respiratory reserve, increased shunting and propensity for airway closure. This, coupled with the relative increased oxygen consumption leads to rapid hypoxemia when ventilation is sub-optimal. Induction may be slow in the presence of alveolar hypoventilation secondary to airway obstruction.

PHARMACOLOGY

With the exception of muscle relaxants, the main purpose of pharmacological agents for patients undergoing bronchoscopy is the blockade of undesirable physiologic responses associated with airway manipulation such as coughing, gagging, laryngospasm, bronchospasm, hypertension, bradycardia and tachycardia. Anticholinergics are usually given prior to bronchoscopy for reduction of airway secretions, attenuation of vagal-mediated bradycardia and blockade of reflex broncho-constriction. Local anaesthetics such as lignocaine can be given topically to diminish airway reflexes. Narcotic analgesics (fentanyl 1 μg/kg) provide a high degree or airway reflex suppression but must be used judiciously in children once the airway is secured. Amongst the inhalational agents, sevoflurane with 100% oxygen remains the agent of choice for smooth inhalational induction; isoflurane may be substituted once a deeper plane of anaesthesia is reached. Sedatives and hypnotics may be used judiciously once the airway is secured to supplement anaesthesia. Propofol is especially useful because of its rapid recovery profits coupled with good reflex suppression.

SYMPTOMS AND SIGNS

Coughing, wheezing, dyspnoea and decreased air entry on the affected side are indicative of bronchial aspiration. Dyspnoea, stridor, coughing and cyanosis are more common with laryngeal or tracheal foreign body[5]. Aphonia is of particular concern because it may suggest totally obstructive laryngeal foreign body.

As most inhaled foreign bodies are radiolucent, clues as to their location on radiographs depends on secondary signs of complete or partial airway obstruction[6]. Surprisingly, many chest radiographs may have completely negative findings, especially within the first 24 hours following aspiration[2,3]. A positive history plus clinical symptoms of aspiration may be sufficient to justify endoscopy for diagnosis and retrieval of the foreign body.

PRE-OPERATIVE ASSESSMENT

Assessment of the patient's respiratory status should include the severity of airway obstruction, gas exchange and level of consciousness prior to anaesthetising the child for foreign body removal[8]. The nature and location of foreign body as well as oral intake status must be reviewed. The latest radiographs (inspiratory/ expiratory/decubitus) are helpful in determining the location of foreign body and for evidence of secondary pathologic change: atelectasis, air-trapping with mediastinal shift or pneumonia. In the presence of significant hyperinflation of one lung or lobe, nitrous oxide should be withheld due to potential danger of a further increase in gas volume and rupture of the affected lung[7].

The urgency with which to proceed with anaesthesia and bronchoscopic foreign body removal is dictated by the severity of respiratory distress[6]. Foreign objects retained in the larynx or trachea cause considerably more distress and are associated with higher mortality (45%) than objects lodged peripherally[9,10,11]. The former are also more treacherous, potentially moving from one part of the airway to another thus causing a sudden complete airway occlusion[6].

PRE-OPERATIVE CONSIDERATIONS

Sedative pre-medication may be contra-indicated in a child with potential airway obstruction despite the high level of anxiety that is often present. However, anticholinergic medication such as atropine is advisable especially in infants to decrease secretions and prevent reflex bradycardia during airway instrumentation.

If the patient is not adequately fasted, there is a risk of aspiration during induction. This hazard diminishes with an increasing time interval between eating and induction. Therefore, the advantages of delaying intervention must be balanced against the potential functional impairment due to the presence of the foreign body. In the unusual situation where the foreign body has been present for a long time and the patient is not in distress, it may be advisable to wait three to four hours after drinking or six hours if milk or solids have been ingested, when there are acute signs of decompensation, urgent removal of the foreign body is more important than adhering to the fasting requirements. In an emergency situation when the patient is in severe respiratory distress due to ineffective ventilation, a trial of Heimlich maneuvre may be a life saving procedure.

TYPES OF ANAESTHESIA

A decision on topical or general anaesthetic is dictated by the patient's apprehension, clinical status as well as size and location of the foreign body. In a child, unless moribund, a general anesthesia is almost always necessary especially in doing a rigid bronchoscope. Removal of a distally lodged and invisible foreign body may involve a prolonged bronchoscopy and will require general anaesthesia induced either by intravenous or inhalational technique.

Spontaneous respiration is safer than the apnoeic technique with complete neuromuscular paralysis. Positive pressure ventilation may drive the foreign body further peripherally[12]. During spontaneous respiration, sevoflurane in 100% oxygen is insufflated during actual attempts of extraction reinforced by topical lignocaine in the larynx, trachea and bronchi (3 to 5 % in most instances). As anaesthesia is deepened, special care should be taken to preserve spontaneous ventilation, at least until the nature and location of the foreign body have been determined by bronchoscopic examination[1,3]. Coughing, occurring if anaesthesia lightens may help move the foreign body towards the bronchoscope, but at the same time may make it more difficult for the endoscopist to grasp the object.

The endoscopist should first expose the larynx in case the foreign body is present in the larynx or hypopharynx[13]. The bronchoscope is then inserted and the tracheobronchial tree is inspected while the patient is anaesthetized and has his spontaneous breaths assisted through the bronchoscope side arm. At this point, if the patient coughs, a small increment of propofol or fentanyl may be administered. If bradycardia is encountered or there is any evidence of hypoxia, priority for management must be given to the anaesthetist and adequate ventilation established.

CHILD IN STABLE CONDITION

Atropine premedication should be given in the ward. Intravenous access is achieved before induction. The child is monitored with pulse oximeter, precordial stethoscope, electrocardiography and non-invasive blood pressure monitoring. After induction, temperature and end-tidal carbon dioxide monitoring are added. General anaesthesia is induced with thiopentone (4-6 mg/kg), with or without fentanyl (0.5-1.0 μg/kg). This is followed by atracurium (0.3-0.5 mg/kg), vecuronium (0.07-0.1 mg/kg), or mivacurium (0.2-0.3 mg/kg), depending on the duration of

the procedure. Intravenous induction and neuromuscular blockade is appropriate only if the anaesthetist is absolutely sure that there is no air-trapping potential since positive pressure ventilation can result in emphysema and rupture if this is present. General anaesthesia is maintained with sevoflurane or isoflurane while the child is manually ventilated. The stomach is emptied and the child positioned for direct laryngoscopy and bronchoscopy. The anaesthetic circuit is connected to the ventilating side-arm of the bronchoscope for ventilation. The inspiratory gas flow is adjusted to compensate for the leak around the bronchoscope.

CHILD WITH RESPIRATORY DISTRESS AND HYPOXAEMLA

A child, with aspiration, who is cyanotic and has signs of severe inspiratory and expiratory obstruction should receive 100% oxygen and should be taken directly to the operating room for the immediate attention of the anaesthetist and the endoscopist[3,14].

When respiratory distress is severe, the child may be induced in the sitting position with sevoflurane and oxygen by mask. Monitors used are as described in a child with stable condition. Intravenous access is established if not already available. Intravenous atropine is given. Patience and time are needed for the prolonged inhalation induction that is required when a main bronchus is obstructed[6]. General anaesthetic is deepened while ventilation is assisted by mask and bag. This may be a slow process if there is poor ventilation secondary to the obstruction.

As soon as the child is anaesthetized, direct laryngoscopy is carried out and a bronchoscope inserted. No muscle relaxants are given unless the airway is secured and there is no danger of dislodging the foreign body distally with manual ventilation.

CHILD WITH SUSPECTED FULL STOMACH/ SEVERE RESPIRATORY DISTRESS

In this situation, the risk of aspiration from a full stomach must be minimized. After establishing intravenous access, a vagolytic dose of atropine is given followed by preoxygenation and a rapid sequence induction with thiopentone and succinylcholine with cricoid pressure. The airway is secured with an endotracheal tube. The endoscopist then positions himself to insert the rigid bronchoscope. Only when the glottis is in direct vision does the anesthetist withdraw the endotracheal tube to allow immediate insertion of the bronchoscope.

LARGE FOREIGN BODY IN TRACHEA

When a large obstructive foreign body is removed from the bronchus and is dislodged in the trachea or larynx during the retrieval process, serious obstruction of the entire airway may ensue if it is not removed immediately. If this is not possible, the foreign body should be pushed back into one of the main bronchus so that ventilation can resume using at least one lung[13].

INTRA-OPERATIVE MONITORING

Attention should be focused on breath sounds by precordial stethoscope, respiratory excursion on both sides of the chest by inspection, oxygen saturation with pulse oximeter, and end-tidal carbon dioxide trace that demonstrate effective ventilation. Neuro-muscular transmission should be monitored with a train-of-four nerve stimulator if a muscle relaxant is administered. While it is preferable to dim the room lights to assist endoscopy, one overhead spotlight should be directed towards the anaesthetic machine and a second on the child's feet to aid assessing saturation and perfusion[1].

The same narrow airway through the bronchoscope is shared for gas exchange and instrumentation. Ventilation may be compromised by too large a telescope, too distal insertion of the bronchoscope in the bronchial tree or prolonged apnoea during attempts to grasp the foreign body. In this situation, the endoscopist should pause momentarily until the patient is adequately ventilated. Arterial carbon dioxide tension rises at a rate of about 10 mm Hg per minute[15], so that periods of apnoea or hypoventilation should not exceed more than one minute during bronchoscopy.

The anaesthetist must ensure that during active ventilation, the telescope or forceps is removed, the distal end of the bronchoscope is pulled back to the mid-portion of the trachea, and the proximal open end is occluded with the endoscopist's thumb or a glass obturator. The child is then hyperventilated for at least one minute and oxygen saturation readings must reach their baseline levels before re-instrumentation. Very occasionally, during the crucial moment of foreign body retrieval, ventilation may need to be delayed so long as the oxygenation is adequate.

When the foreign body is successfully grasped, the forceps and bronchoscope are withdrawn from the trachea and larynx as a single unit through the immobile vocal folds. It is important that the upper airway and the glottis are totally relaxed and offer minimal resistance for the foreign body to pass without being dislodged prematurely. Administration of succinylcholine 0.25-0.50 mg/kg intravenously can provide brief relaxation[1]. The patient is then ventilated by mask and bag until the bronchoscope is reintroduced into the trachea. This maneuver may be repeated if the foreign body is fragmented.

If the foreign body is lost during the attempted removal, the pharynx should be inspected immediately. If the foreign body is not located, the bronchoscope

should then be reintroduced and the object sought in the larynx or trachea. A prematurely dislodged foreign body tends to fall back into the good lung, resulting in poor ventilation in both lungs. In the event of tracheal obstruction, the foreign body must be removed immediately or pushed back to its original location in order to achieve ventilation[13].

INSTRUMENT PROBLEMS

Laryngoscopy and bronchoscopy, usually done as a paired examination, can present a multitude of potential problems that arise from the anaesthetist having to share the airway with the endoscopist, while maintaining alveolar ventilation and providing an unobstructed surgical view and access[6].

The rigid ventilating bronchoscope equipped with an optical telescope and incorporated fiberoptic light source is the most appropriate for paediatric airway examination. The development of the Hopkins rod lens optical telescope used with the Storz paediatric bronchoscope gives superior resolution, magnification and wide-angle view. Miniature grasping forceps can be manipulated through the instrument channel while a closed system is maintained for ventilation with the viewing telescope in place. The sidearm makes it possible to fit the ventilating bronchoscope to any anaesthetic system in order to maintain anaesthesia, oxygenation and assisted or controlled manual ventilation.

The optical telescope occupies nearly the entire internal lumen of the smaller bronchosopes. The consequences of this design are decrease in the area for gas flow with marked increases in airflow resistance and a potential for retarding passive expiraton[6]. It results in hyperinflation of the lungs and hypoventilation[16,17]. For particularly long bronchoscopic procedures, it is helpful to obtain several spot checks of $PaCO_2$ to confirm the adequacy of ventilation[6].

INTRA-OPERATIVE COMPLICATIONS

Laryngospasm, bronchospasm, pneumothorax and cardiac arrhythmias may occur. Most of these complications are related to impaired ventilation and can be avoided by maintaining adequate anaesthesia, using atropine to minimise secretions and providing muscle relaxation when appropriate, adequate ventilation and oxygenation. Pulse oximetry is vital for monitoring oxygen saturation during the procedure. Arrhythmias associated with hypercarbia may be treated by hyperventilation and intravenous lignocaine (1 mg/kg). If acute deterioration of ventilation and gas exchange occurs, pneumothorax, albeit infrequent, must be considered. A portable chest radiograph is diagnostic, and a chest tube is inserted to re-expand the lung. In the event of rapid cardiac deterioration during bronchoscopic manipulation, one should be highly suspicious of a tension pneumothorax, clinical findings alone justify decompression with venous cannula followed by chest tube insertion, thus avoiding the hazardous delay of radiographic diagnosis.

END OF FOREIGN BODY REMOVAL

Trauma to the airway may produce mucosal oedema with respiratory distress. The child may be intubated for tracheo-bronchial toilet and ventilation until adequate spontaneous breathing occurs following reversal of muscle relaxation or when mucosal oedema subsides. Measures to minimize post-operative stridor and distress include administration of dexamethasone (0.1- 0.25 mg/kg) prophylactically for laryngeal oedema, although its efficacy is controversial[18,19]. Humidified oxygen and nebulised racemic epinephrine (2.25% solution given in a 1:6 to 1:10 dilution) accompanied by electrocardiograph monitoring up to every 2 hours[20,21,22] may be used. Rarely, intubation for one or two days may be necessary until oedema subsides[1].

CONCLUSION

The problems and challenges are multiple and difficult in a child with an airway foreign body. Complete co-operation and good communication between the endoscopist and anaesthetist is vital in achieving an optimal outcome.

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INTERNATIONAL SOCIETY FOR BEHCET'S DISEASE

A multidisciplinary society was inaugurated at the 9th International Congress for Behcet's Disease (BD) in Seoul, South Korea, on the 28th May 2000. The aim for the society is to advance the knowledge of the aetiology, pathogenesis, diagnosis, natural history, clinical features, treatment and management of Behcet's Disease. The Executive Committee is:

Dr Colin G Barnes (UK)	-	President
Professor Hasan Yazici (Turkey)	-	President
Elect and Secretary		
Professor Sungnack Lee (Korea)	-	Vice-President
Professor Dorian Haskard (UK)	-	Treasurer
Professor Christos Zouboulis (Germany)	-	President of the 10th International
Congress, Berlin, June 2000		
Professor Shigeaki OHNO (Japan)	-	to represent Ophthalmology

Due to the diverse clinical manifestations of BD the founder members of the society include dermatologists, epidemiologists, gastroenterologists, immunologists, internal medicine physicians, neurologists, ophthalmologists, pathologists and rheumatologists. Colleagues from any interested discipline, including non-medical scientists, are encouraged to become members. Details are available from the Secretary.

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The 10th International Congress on Behcet's Disease will be held in Berlin, 27-29 June 2002. Details will be available from:

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