Large airway obstruction in children


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PART 1: CAUSES AND ASSESSMENT
Opening and maintaining the airway is fundamental to the treatment of all emergency situations in paediatrics, as in adults. All resuscitation algorithms start with ABC (Airway, Breathing, Circulation) and must be qualified in trauma to include cervical spine control. The commonest cause of paediatric airway obstruction is still the child with depressed conscious level who is not positioned properly or whose airway is not opened adequately by Basic Life Support manoeuvres. Airway foreign bodies are also common and may need rapid intervention. The pattern of infective causes of airway obstruction has changed since the introduction of vaccination programmes against Haemophilus influenzae type B. There has been a marked reduction in the incidence of epiglottitis, with a relative predominance now of viral croup and bacterial tracheitis, usually caused by Staphylococcus aureus.

Why are children at increased risk from airway obstruction?
There are anatomical, physiological and developmental reasons for children to be particularly susceptible to airway obstruction.

Rapid clinical assessment, minimal disturbance, and rapid intervention are important. Summon senior experienced help if available.

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Summary
There are anatomical, physiological and developmental reasons for children to be particularly susceptible to airway obstruction.

Rapid clinical assessment, minimal disturbance, and rapid intervention are important. Summon senior experienced help if available.
compression more readily lead to airway closure and either atelectasis or gas trapping. The interalveolar pores and bronchoalveolar channels do not develop until the ages of 1 year and 8 years respectively so collateral ventilation is not an option around an area of obstruction by these mechanisms.

Thus anatomical, physiological and developmental factors conspire to make the child susceptible to airway obstruction and is exacerbated in disease states (Table 1).

**What are the symptoms and signs of airway obstruction?**

**Signs of foreign body aspiration**
Sudden onset of respiratory compromise associated with coughing, gagging, choking, aphony or stridor suggests foreign body aspiration and this may necessitate emergency basic life support measures for the choking child. Signs of gas trapping behind a foreign body (“ball-valve effect”) may be seen with hyper-resonance of the hemithorax, loss of percussion dullness over the liver, surgical emphysema, tracheal deviation and unequal breath sounds. It is particularly important to think of the possibility of pneumothorax and actively exclude it and treat it promptly. Pneumomediastinum, pneumopericardium and pneumoperitoneum may be seen. Collapse or consolidation of lobes or lungs with bronchial breathing, widespread crackles and expiratory wheeze may all be elicited depending on the cause, site and duration of the airway obstruction.

**Signs of increased work of breathing**
The increased effort of breathing caused by airway obstruction may produce an increase in respiratory rate for age. A rate >50bpm in an infant and >30bpm in a child may be considered abnormal. However, of even more concern would be respiratory distress associated with a normal respiratory rate, bradypnoea or apnoeic spells which indicate decompensation and exhaustion.

A “see-saw” pattern of chest and abdominal breathing movements is seen in airway obstruction. This sign occurs earlier in younger infants. Recession of the intercostal spaces, subcostal region and sternum are also seen early in young infants and reflect the forces generated by vigorous contractions of the diaphragm and the compliant chest wall. If recessions are seen in older children they indicate severe airway obstruction. Use of the accessory muscles of inspiration (sternomastoids, scalene muscles and intercostals) is associated with tracheal tug, suprasternal and supraclavicular recessions and nasal flaring. Often the child sits upright and may adopt the “tripod” position to improve the mechanical advantage of these muscles in moving the chest wall and that of the diaphragm. In the small infant, an opisthotonic posture may be seen in airway obstruction and head bobbing is a sign of accessory muscle contraction in the infant. Lack of effort associated with deteriorating conscious level may indicate exhaustion and decompensation.

**Expiratory grunting** is often noted in infants with respiratory distress who are trying to generate auto-CPAP or expiratory braking at laryngeal level to maintain a residual lung volume at end expiration. Stridor during inspiration is usually a sign of airway obstruction at supraglottic or laryngeal level but can occur in tracheal obstruction also. Stridor during expiration is usually a sign of intrathoracic airway obstruction. Prolonged expiration with wheeze is usually a sign of small airways obstruction as in bronchiolitis or asthma but can occur in large airway obstruction especially due to foreign body or if there is an underlying anatomical abnormality. The volume of stridor or wheeze does not correlate with the degree of airway obstruction. Indeed, the most ominous sign is the “silent chest” where obstruction is so severe that no gas flow is occurring.

**Signs of ineffective breathing**
Cyanosis, depression of conscious level, slow respiratory rate, the

<table>
<thead>
<tr>
<th>Table 1. Some causes of large airway obstruction in children</th>
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<tbody>
<tr>
<td>Depressed conscious level</td>
</tr>
<tr>
<td>Foreign body</td>
</tr>
<tr>
<td>Infection</td>
</tr>
<tr>
<td>• Viral: croup, papillomatosis</td>
</tr>
<tr>
<td>• Bacterial: epiglottitis, tracheitis, tonsillitis, abscess</td>
</tr>
<tr>
<td>• Adjacent to airway</td>
</tr>
<tr>
<td>Trauma</td>
</tr>
<tr>
<td>Thermal injury</td>
</tr>
<tr>
<td>Congenital abnormalities: choanal atresia, choanal stenosis,</td>
</tr>
<tr>
<td>micrognathia, macroglossia, laryngomalacia, laryngeal web</td>
</tr>
<tr>
<td>Neoplasm: haemangioma, lymphoma, mediastinal mass</td>
</tr>
<tr>
<td>Peripheral neurological disease</td>
</tr>
<tr>
<td>Neuromuscular disease</td>
</tr>
<tr>
<td>Iatrogenic: subglottic stenosis, post-intubation stridor,</td>
</tr>
<tr>
<td>neck haematoma</td>
</tr>
<tr>
<td>Anaphylactoid reactions</td>
</tr>
</tbody>
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silent chest despite vigorous respiratory efforts or lack of adequate respiratory effort, apnoeic spells and bradycardia are most worrying signs of ineffective breathing.

**Secondary effects of airway obstruction**

Airway obstruction may produce hypoxaemia and hypercarbia. Tachycardia, sweating, confusion, restlessness, agitation, anxiety, dyspnoea, inability to speak, peripheral vasoconstriction with pallor or mottling, cyanosis, decreased conscious level, apnoeic spells and bradycardia may occur. Generalised convulsions may occur secondary to hypoxaemia. Hypertension and bounding pulses may be felt and pulps paradoxus of greater than 20 mmHg may be elicited in older children. Chronic airway obstruction may cause chest wall abnormalities, pulmonary hypertension, right heart failure and obstructive sleep apnoea syndrome.

**What investigations are helpful?**

The assessment of the child in order to identify and manage airway obstruction is a clinical one. Do not try to examine the child’s throat. The pulse oximeter is a very helpful, non-invasive and atraumatic monitor of arterial oxyhaemoglobin saturation and heart rate. However, the readings need interpretation in context with the clinical picture as they are affected by poor perfusion, movement, ambient light and carboxyhaemoglobinaemia (as may occur in smoke inhalation injury) and are less accurate at values below 70%.

Radiology should not be used in the child in extremis before intervening but in the less acute situation may help elucidate chest signs, such as pneumothorax, consolidation, collapse, foreign body, steeple sign in croup, mediastinal mass, etc. It should be carried out at the bedside.

Lateral soft tissue neck films are seldom indicated but may show a foreign body, thumb sign of epiglottitis, prevertebral or a retropharyngeal abscess. CT and MRI scanning have no place in emergency management but are very helpful in cases such as haemangioma, mediastinal mass, or abscess adjacent to the airway. The process of obtaining arterial, capillary or venous blood gases is likely to cause undue distress which will worsen airway obstruction. In the obtunded child intervention should be immediate and should not await blood gas results. For less severe cases, trends in carbon dioxide levels, pH and oxygen values may be helpful in guiding treatment and in reinforcing the need to intervene. Chronic airway obstruction leads to a respiratory acidosis which induces renal compensatory mechanisms with retention of bicarbonate and a metabolic alkalosis reflected in a high serum bicarbonate level and often a near normal arterial pH.

**Making the diagnosis**

Some features of the history and examination may be particularly helpful in pointing to a specific diagnosis and they are summarised in Table 2. These clinical signs are suggestive only as each disease process has a spectrum of severity. In individual cases it can be difficult to differentiate between the infective causes and foreign body aspiration. Severe tonsillitis or abscesses near the airway can produce similar symptoms and signs. Oedema of the face, periorbital tissues, tongue and peripheries is suggestive of angioneurotic oedema or anaphylactoid reactions.

**Severity scoring system**

A scoring system for croup (Table 3) is helpful in assessing severity, response to therapy and of the need for intervention.

### Table 2. Differentiation between croup, tracheitis and epiglottitis

<table>
<thead>
<tr>
<th>Cause</th>
<th>Croup</th>
<th>Tracheitis</th>
<th>Epiglottitis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cause</strong></td>
<td>Viral</td>
<td>Staphylococcus aureus Streptococcus</td>
<td>Haemophilus influenzae B</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>6m – 3y</td>
<td>Any age</td>
<td>2 – 6y</td>
</tr>
<tr>
<td><strong>Onset</strong></td>
<td>Gradual</td>
<td>Gradual</td>
<td>Sudden</td>
</tr>
<tr>
<td><strong>Pyrexia</strong></td>
<td>Mild</td>
<td>&gt;38°C</td>
<td>&gt;38°C</td>
</tr>
<tr>
<td><strong>Abnormal sounds</strong></td>
<td>Barky cough, stridor</td>
<td>Barky cough, stridor</td>
<td>Muffled, guttural cough</td>
</tr>
<tr>
<td><strong>Swallowing</strong></td>
<td>Normal</td>
<td>Difficult</td>
<td>Very difficult with drooling</td>
</tr>
<tr>
<td><strong>Posture</strong></td>
<td>Recumbent</td>
<td>Sitting</td>
<td>Tripod position</td>
</tr>
<tr>
<td><strong>Facies</strong></td>
<td>Normal</td>
<td>Anxious</td>
<td>Anxious, distressed, toxaemic</td>
</tr>
</tbody>
</table>

### Table 3. Croup score

<table>
<thead>
<tr>
<th>Breath sounds</th>
<th>Stridor</th>
<th>Cough</th>
<th>Retractions/ flaring</th>
<th>Cyanosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Normal</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1</td>
<td>Harsh, rhonchi</td>
<td>Inspiratory</td>
<td>Hoarse cry</td>
<td>Flaring + suprasternal retractions</td>
</tr>
<tr>
<td>2</td>
<td>Delayed</td>
<td>Insp. + Exp.</td>
<td>Bark</td>
<td>Flaring + suprasternal + intercostal retractions</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In 40% oxygen</td>
</tr>
</tbody>
</table>
Paediatric Large Airways Obstruction

CALL FOR SENIOR EXPERIENCED HELP AS PER LOCAL PROTOCOL

CLINICAL ASSESSMENT

IMMEDIATE INTERVENTION REQUIRED?

NO

MEASURES TO BUY TIME

CHRONIC AIRWAY OBSTRUCTION ANATOMICAL ABNORMALITY

OXYGEN HUMIDITY NEBULISED ADRENALINE STEROIDS CPAP HELIUM

YES

FOREIGN BODY ASPIRATIONS

BASIC LIFE SUPPORT

OPEN AIRWAY OXYGENATE SUPPORT INADEQUATE VENTILATORY EFFORTS

ADVANCED LIFE SUPPORT

DRAIN TENSION PNEUMOTHORAX

BRONCHOSCOPY

CHOKING CHILD PROTOCOL

BACK BLOWS CHEST COMPRESSIONS ABDOMINAL THRUSTS

ADVANCED LIFE SUPPORT

INHALATIONAL TECHNIQUE IV ACCESS

CRICOTHYROTOMY

FAILED INTUBATION PROTOCOL

ENDOTRACHEAL INTUBATION

DIFFICULT INTUBATION PROTOCOL

TRACHEOTOMY

POST-INTUBATION INTENSIVE CARE
PART 2: MANAGEMENT

Importance of rapid clinical assessment, minimal disturbance and rapid intervention

An assessment from the end of the bed with minimal disturbance should be possible in most cases with the child sitting in the parent’s arms and the child should be allowed to adopt the posture in which they are most comfortable. Clinical assessment and a concise history as described in part 1 should allow identification of the need for intervention. A pulse oximeter probe is relatively atraumatic to apply. Gentle physical examination of the chest seeking actively for the important signs described in part 1 should be possible. In some cases, the need for immediate intervention will be obvious. In others, measures to buy time to enable experienced help to arrive may be appropriate. It is often stated that attempts at venous access should not be made as they will upset the child - this is a reasonable view. However, some argue that, in the less ill child and with topical local anaesthesia or ice analgesia of the skin and a skilled paediatric venepuncturist, this is not an issue. Some experienced paediatric anaesthetists are of the view that, in the hypercarbic, obtunded child they are most comfortable. Clinical assessment and a deliberate history and some mediastinal masses. They can be given orally, parenterally or by nebuliser. Prednisolone 4mg.kg⁻¹ orally, or dexamethasone 0.6mg.kg⁻¹ intravenously or intramuscularly, or budesonide 1-2mg by nebuliser are favoured as initial therapy with maintenance by repeated nebuliser therapy or oral prednisolone or parenteral dexamethasone at one quarter of the initial dose every 8-12h for up to 48h. Prompt administration of steroids often pre-empts the need for intubation in most cases of moderate or severe croup.

Nebulised adrenaline 1:1000 standard solution at a dose of 0.5ml.kg⁻¹ (maximum 5ml) diluted if necessary with 0.9% saline to a total volume of 5ml will give a dose of 2-5mg in most cases. It reduces mucosal oedema and acts very rapidly but when stopped may give rise to a rebound worsening of airway obstruction. It is a useful temporising measure. ECG monitoring is recommended although dysrhythmias are seldom a problem.

CPAP - Continuous positive airway pressure acts as an effective splint for the collapsible, compressible paediatric upper airway and can be delivered to infants and children by a well fitting facemask (especially using the Jackson-Rees T-piece circuit) and, in babies, by nasal cannulae, nasal prongs or a nasopharyngeal airway. It is a very useful measure particularly during the preparation phase prior to intubation and during inhalational induction of anaesthesia. It can be very useful in the management of chronic airway obstruction. A development of CPAP is bi-level CPAP or BIPAP; it is becoming increasingly popular in the management of children.

Prone position +/- nasopharyngeal airway can be useful in babies with congenital upper airway abnormalities where the tongue is relatively large e.g. hemifacial microsomia, Pierre-Robin syndrome, or Treacher-Collins syndrome. The tongue falls forward from the posterior pharyngeal wall and often improves the airway. In conjunction with nasal CPAP and /or a nasopharyngeal airway, the child may improve markedly with this simple manoeuvre.

Helium is less dense than air or oxygen and gas flow tends to be more laminar which reduces the work of breathing. However, it is not readily available, is expensive and dilutes the inspired oxygen concentration. Breathing a helium-oxygen mixture may be helpful in buying time.

How should I intervene to open and secure the airway?

The algorithm in Figure 1 is a useful guide. If possible, call for expert help.

Basic life support manoeuvres and the choking child

Head tilt, chin lift and jaw thrust are the first basic steps. Physical methods of clearing the airway should only be used if the diagnosis of foreign body aspiration is clear and dyspnoea is increasing rapidly or apnoea has occurred. Do not use finger sweeps as this may push the foreign body further down the airway and may impact it in the laryngeal inlet. Do not try to examine the throat. In infants, immediately carry out five back blows with the heel of the hand with the infant lying prone and head down along your arm which should be resting along your thigh. If the obstruction remains, turn the baby supine and give five chest thrusts as for cardiac compression but more slowly and repeat airway opening manoeuvres, expired air ventilation and cardiac compressions as appropriate. In older infants and children, five back blows with the child prone across the lap and up to five abdominal thrusts exactly in the midline with the child standing, kneeling, sitting or supine should be used.

Advanced life support manoeuvres

Oxygen 100% should be administered by self-inflating bag and mask or anaesthetic T-piece circuit, depending on familiarity. The latter has the advantage that CPAP can easily be applied and the transition from spontaneous to controlled ventilation is simple. It is very important to actively exclude tension pneumothorax and, if present, to intervene with a needle, cannula or drain. This can be inserted under local anaesthesia in the conscious child giving careful attention to technique. Some distress may be caused to the child but this is transient and justifiable in the emergency situation. In the context of a tension pneumothorax secondary to acute airway obstruction, it is very wise to drain the pneumothorax prior to inducing anaesthesia. However, circumstances may dictate simultaneous intervention to drain the pneumothorax and induce anaesthesia to secure the airway if rapid decompenesation is occurring.

Endotracheal intubation technique

It is better to have the child in an intensive care or operating theatre
Large airway obstruction in children is a common emergency. If intubation is difficult or impossible, a number of techniques using the flexible fiberoptic or rigid bronchoscope are possible and very occasionally blind or retrograde intubation techniques may be employed. The use of a nasopharyngeal airway or the laryngeal mask airway may be helpful in certain cases. All these techniques are for the expert only.

In certain cases of impossible intubation where the child is rapidly deteriorating, the safest option may be to consider an emergency cricothyrotomy using a cannula, 3mm endotracheal tube connector, a T-piece or self-inflating bag and oxygen source. Remember that there must also be a patent expiratory pathway to avoid barotrauma. Carbon dioxide levels will tend to rise with this technique. Jet ventilation is not recommended in children due to the risks of overpressure and barotrauma. In other cases, particularly of severe anatomical abnormalities, the safest option may be an emergency tracheostomy under mask anaesthesia and or local infiltration analgesia.

**When should I not intervene?**

If you are inexperienced with advanced life support measures in children, you should try to maintain oxygenation, airway patency and ventilatory support with basic measures until experienced staff arrive. Advanced life support interventions should be carried out by the most experienced staff present. However, you may have to intervene in the extreme situation to save the child’s life. If it is available, it is vital that expert help is called as early as possible to manage children with airway obstruction.

**How should I manage the child after the airway is secured?**

It is important to ensure that the artificial airway is fixed securely and is correctly positioned. A post-intubation chest X-ray is useful for checking tube position and identifying lower respiratory tract or pulmonary parenchymal changes. Indications for controlling ventilation rather than allowing spontaneous ventilation are:

- Small diameter endotracheal tube
- Child with signs of septicaemia
- Lower respiratory or lung disease
- Child who has sustained a hypoxic insult
- Very abnormal, inflamed or oedematous airway
- Traumatic intubation
- Need to transport the child to another hospital

Sedation, analgesia and muscle relaxation should be given as appropriate. Some children develop post-intubation pulmonary oedema which requires ventilatory support with PEEP and diuretic therapy.

Antibiotic therapy is indicated for likely organisms - the third or fourth generation cephalosporins are favoured with some preferring flucloxacillin for staphylococcal tracheitis. Duration of intubation varies widely from 18-24 hours for acute epiglottitis to days or weeks for those with lung involvement, severe disease and pre-existing congenital anomalies. Some children may require formal investigation of their airway eg endoscopy, foreign body removal or reconstructive surgery.

**CONCLUSION**

Large airway obstruction in children is a common emergency. If available, senior experienced help should be summoned immediately. Therapy is guided by clinical assessments. All consultants should be competent in the performance of basic life support measures for the choking child and for opening the airway, oxygenating the child and supporting inadequate ventilation. Measures to buy time can be very helpful in coughing and where the airway anatomy is abnormal. Advanced life support measures are for experienced staff but you may have to intervene immediately to save a child’s life. The results of correct management are excellent.

**FURTHER READING**
