

PAEDIATRIC AIRWAY PROBLEMS AND ANAESTHESIA

Brig. M Salim, (Retd),SI(M)

Professor of Anaesthesiology
Islamic International Medical College, Rawalpindi

ANAESTHESIA AND PHYSIOLOGICAL CONSIDERATIONS

Certain normal anatomical and physiological difference between young infants and older children are important when considering airway obstruction;

In neonates and young infants the tongue is large relative to the size of oropharynx. Some pathologic disorders will exaggerate this difference e.g. micrognathia; or obstruct the nasal airway e.g. choanal atresia, and will also lead to upper airway obstruction in this age group.

The narrowest part of the upper airway is the cricoid ring in children under 10 years. In adults the larynx at the level of the vocal cords is the narrowest part. The mucosa at cricoid level is more prone to aedema than the mucosa at vocal cord level. Damage from tracheal intubation is more likely.

The small size of the paediatric airway makes small amounts of oedema more serious (resistance $1/r^4$)

The cartilaginous structures of the tracheobronchial tree are relatively soft, so extra-luminal compression e.g. vascular ring is likely to distort the lumen

The chest wall is more compliant in young children, therefore they are at a mechanical disadvantage in the presence of airway obstruction. Recession and indrawing are more marked in infants.

Oxygen consumption (per kg) is similar but respiratory rates are higher, therefore hypoxia occurs more quickly in the presence of obstruction or apnoea.

The ribs are more horizontal, so respiration is largely dependent on diaphragmatic activity and accessory muscles are relatively ineffective.

The respiratory muscles are more prone to fatigue in the very young infant.

A straight bladed laryngoscope is often recommended for neonates and young infants because of the position and structure of the larynx and epiglottis in this age group.

AIRWAY OBSTRUCTION

The causes of airway obstruction are many and varied, ranging from acute to chronic and are usually classified as congenital or acquired. Obstruction can occur at any of the following sites;

- Nasopharynx
- Oropharynx
- Larynx
- Trachea

The causes of airway obstruction are listed in table 1(adapted from Recent Advances in Anaesthesia and Analgesia, Atkinson RS, Adams AP, Eds)(1). Enlargement of the adenoids and tonsils is the commonest cause of chronic upper airway obstruction and sleep apnoea in children, whereas laryngomalacia (a floppy larynx) is by far the commonest cause of acquired stridor in young children.

ASSESSMENT OF AIRWAY OBSTRUCTION

Signs of Obstruction

Stridor Because of dynamic changes in airway diameter (i.e secondary to changes in pleural pressure with respiration) inspiratory stridor suggests extrathoracic obstruction e.g. laryngomalacia, and expiratory stridor suggests intrathoracic obstruction e.g. tracheomalacia. Biphaseic stridor usually occurs with "fixed" lesions of the airway such as subglottic stenosis. Co-existing hoarseness suggests laryngeal pathology.

Table 1: Causes of airway obstruction

Site	neonate/young infant	Older child
ACQUIRED		
Nose	nasal congestion Nasogastric tube	
Pharynx		Thermal and chemical burns retropharyngeal abscess angioneurotic oedema Enlarged adenoids and tonsils
Larynx		Laryngospasm Acquired vocal cord palsy Croup Epiglottitis Post-intubation oedema, Subglottic stenosis, webs and granulations foreign body diphtheria tracheitis
Trachea		foreign body bacterial tracheitis mediastinal tumours
CONGENITAL		
Nose	Choanal atresia	
Pharynx	Pierre-Robin anomaly Cystic hygroma	Macroglossia Mucopolysaccharidoses (eg Hurler's) rare syndromes with deformity
Larynx	Laryngomalacia	papillomata congenital subglottic stenosis, webs, cysts, haemangiomas congenital vocal cord palsy
Trachea	Tracheomalacia	Vascular rings

- *Recession of the intercostals, supraclavicular and subdiaphragmatic areas*

- *Tachypnoea (>60/min in infants and >40/min in older children should give rise to concern)*

- *Tachycardia*
- *Flaring of alae nasi and grunting*
- *Impaired ability to feed*
- *Restlessness*
- *Cyanosis*

Assessment is essentially clinical, blood gases play little or no part although oximetry may be helpful. Management of most situations depends upon repeat

observations to assess improvement or deterioration. Only the most acute disorders require immediate intervention (e.g. post extubation laryngospasm, epiglottitis).

The history may be helpful in suggesting the most likely cause and should include;

- The duration and progression of symptoms and any precipitating events;
- Any postural effects
- Feeding difficulties
- Birth history and previous intubation history

Investigation of airway obstruction

- Radiology; lateral x-ray of neck (avoid in unstable patients e.g. epiglottitis) and chest x-ray, barium swallow where vascular ring is suspected
- Diagnostic endoscopy
- Assessment for pulmonary hypertension (ECG, Echo) and sleep studies to identify obstructive apnoea may be indicated in chronic upper airway obstruction

EPIGLOTTITIS, CROUP AND BACTERIAL TRACHEITIS

The majority of paediatric patients with acquired stridor have an infective cause usually laryngotracheobronchitis (croup). The introduction of Hib vaccine has made epiglottitis increasingly rare.

EPIGLOTTITIS

A bacterial infection (usually due to haemophilus influenzae) of supraglottis

Features

- All ages, commonest age 3-6 years
- Marked fever and toxicity
- Stridor (may be minimal), drooling and characteristic sitting posture with open mouth
- Acute airway obstruction may occur. Can be precipitated by examination of pharynx or by physically upsetting child (e.g. taking blood or siting cannula)

Management of epiglottitis

- Avoid disturbing the child to minimize risk of increasing obstruction. Don't x-ray, examine pharynx or take blood. Don't force to lie down.
- Urgent intubation preferably with a competent

ENT surgeon available in case of difficulty. Must be escorted by the anaesthetist with full airway maintenance equipment at hand.

- Preparation of equipment

Equipment for managing the difficult airway including tracheostomy set, and resuscitation drugs should be available

- Introduction of anaesthesia

Halothane in oxygen is safest in the presence of airway obstruction. Starting with the patient in the sitting position

CPAP (continuous positive airway pressure of airway achieved with a close fitting face mask and semi-closed bag on the anaesthetic T-piece circuit) improves gas exchange and airway patency

- Monitoring

Continuous clinical observation

Pulse oximetry

ECG (bradycardia means hypoxia unless proved otherwise)

Blood pressure e.g. NIBP

· Establish i.v. access prior to intubation and consider giving i.v. atropine and fluids.

· Oral intubation without muscle relaxants; bubbles of saliva during spontaneous respiration may be a valuable clue to the location of larynx. A smaller ETT than usual is required

- Blood cultures

· Change oral to securely fixed nasal tube and place nasogastric tube before transfer to ICU

- Antibiotics e.g. 3rd generation cephalosporin

- I.V. fluids and sedation

· Spontaneous respiration with HME or assisted ventilation with humidification.

Relaxants are best avoided.

· Extubate when there is a leak around the tube and the temperature is settled-usually 24-36 hours further laryngoscopy is not necessary.

CROUP OR LARYGOTRACHEBRONCHITIS

Usually viral in origin, mainly parainfluenzae type. Often a mild illness managed in the community.

Features

- Mainly young children, peak incidence in the second year of life
- Mild fever and minimal systemic upset
- Prodromal URTI is common
- Inspiratory and expiratory stridor with barking cough

Management

· The majority of children admitted to hospital will respond to humidified oxygen, intravenous hydration and nebulised adrenaline. Fever should be treated. Steroids should be used in hospitalized patients (3).

· Hospitalized children require close observation. The use of a clinical scoring system helps to identify children who are deteriorating and require intubation. See table 2.

· Children with severe obstruction require intubation

· Nebulised adrenaline prior to intubation may be helpful in reducing the induction time

· Intubation as for epiglottitis –see above. An ETT of proper size should be used that allows a small leak at 30 cmH₂O. Some authorities recommended rapid sequence induction, however this approach is only justified if you are sure that you can ventilate the patient.

- Transfer to ICU

· Antibiotics are not indicated unless secondary bacterial infection

- i.v./n.g. fluids then n.g. feeds

· sedation and either spontaneous ventilation with HME, assisted ventilation with humidification if ETT very small or difficulty with sedation. Paralysis is sometimes required

· Steroids reduce the duration of intubation and risk of failed extubation

· Extubate when increasing leak around ETT. If no leak consider trial of extubation at 4-5 days. Nebulised adrenaline may help post extubation stridor. Reintubation may be necessary. Some centers prefer to extubate under anaesthesia. Repeated failure to extubate is an indication for endoscopy to exclude underlying pathology.

Table 2: Scoring system based on physical signs

	0	1	2
Inspiratory breath sounds	Normal	Harsh with rhonchi	Delayed
Stridor	None	Inspiratory	Inspiratory and expiratory
Cough	None	Hoarse cry	Bark
Retraction and flaring	None	Flaring and suprasternal retractions	+subcostal and intercostals
Cyanosis	None	On air	On 40% oxygen
Sensorium	Normal	Restless	Obtunded

Scores of 7 or more persisting for >30 minutes suggest the need for intubation

BACTERIAL TRACHEITIS

Usually caused by staphylococcus aureus

Features:

- occurs at all ages
- intermediate onset
- fever and systemic upset
- cough and stridor

Management:

· Antibiotics and intravenous fluids. Close observation to detect deterioration that will require intubation. Fever should be treated.

· Children with severe obstruction require intubation

· Bronchoscopy allows confirmation as for epiglottitis/croup

· Extubate when leak around tube, and toxamia resolved

Note:- Propofol should not be used to sedate children in ICU. Deaths have been reported in children with croup like illnesses sedated with propofol. Opiates, benzodiazepines and nasogastric triclofos are suitable.

ANAESTHESIA FOR REMOVAL OF FOREIGN BODIES

This is the commonest indication for bronchoscopy in young children (aged 1-3 years). Many objects and

foods may be aspirated, peanuts are common and cause mucosal irritation.

Presentation of foreign body aspiration:

- Acute episode of coughing +/- cyanosis
- Aphonia suggests the foreign body is lodged in the larynx
- Periods of coughing with stridor or wheezing
- Unexplained worsening asthma or chest infection should raise suspicion even in the absence of a clear history of an acute episode suggestive of aspiration

Investigations:

· X-ray neck and chest. Foreign bodies are occasionally opaque. Secondary infective changes and hyperinflation due to a ball-valve effect of a foreign body in the main bronchus may be apparent especially on expiratory film.

· Endoscopy to confirm diagnosis and remove foreign body

Paediatric Bronchoscopes:

Most specialist centers use ventilating bronchoscopes (e.g. Storz) to which a T-piece is attached permitting spontaneous respiration or manual ventilation with anaesthetic gases. Instruments for removing foreign bodies are available. A telescopic rod passed through the bronchoscope permits detailed examination. The telescope increases resistance to airflow, particularly with size 2.5 bronchoscope. (early versions produced almost complete occlusion).

Negus bronchoscopes, which are commonly used in adults are less satisfactory, as spontaneous respiration or manual ventilation with anaesthetic gases is not practical. Jet ventilation is needed which requires particular care in small children if barotrauma is to be avoided.

Anaesthetic Requirements:

- Adequate oxygenation
- Adequate ventilation
- Satisfactory surgical conditions;

Either spontaneous respiration, free of breath-holding, coughing, laryngospasm and bronchospasm or paralysis and manual ventilation

In general, I prefer to avoid paralysis. There is less difficulty in maintaining oxygenation if the surgeon repeatedly removes the bronchoscope; and you are less

likely to cause barotrauma. Suxamethonium should always be at hand in the case of severe coughing/laryngospasm. Others describe satisfactory techniques using paralysis and hand ventilation.

ANAESTHETIC MANAGEMENT OF BRONCHIAL FOREIGN BODIES

The following lines present a satisfactory approach using Storz bronchoscopes and spontaneous respiration:

- Preoperative assessment
- Preparation of equipment
- Preoperative starvation and premedication usually atropine only
- Induction of anaesthesia

Halothane or sevoflurane in oxygen is the safest in the presence of significant airway obstruction.

- Monitoring

Close continuous clinical observation and praecordial stethoscope, pulse oximeter

ECG

blood pressure e.g. NIBP

- Venous access

· Tracheal intubation prior to bronchoscopy is optimal. It allows the size of the airway to be assessed and facilitates deepening of anaesthesia. Intubation may be achieved using deep anaesthesia or a short acting muscle relaxant (provided mask ventilation is possible).

· Topical anaesthesia with lignocaine (max. dose 4-5 mg/kg) to cords and upper trachea minimizes coughing and laryngospasm during the procedure. (However application of the lignocaine may precipitate acute laryngospasm).

· Bronchoscopy is performed and the foreign body removed using a ventilating bronchoscope (eg Storz) connected to an anaesthetic T-piece. The infant continues to breathe anaesthetic gases spontaneously.

- The procedure may be prolonged

· The surgeon may dislodge the foreign body from one side to the other (observe closely) or may let it fall out of the forceps into the subglottis. In this case it may be necessary to push it back into the main bronchus to permit oxygenation before making a second attempt at removal

· The bronchoscope often has to be removed along with foreign body. Prophylactic steroids are desirable if

repeated instrumentation of the airway

· Humidification, physiotherapy and antibiotics should be considered post-operatively

LARYNGEAL FOREIGN BODIES

· Laryngeal foreign bodies rarely present for removal under general anaesthesia

· Urgent removal is indicated and equipment should be available for immediate tracheostomy if endoscopic removal is not possible

· Laryngoscopy should be performed under deep anaesthesia using halothane or sevoflurane in oxygen

· Steroids should be given if laryngeal damage occurs

DRUG REGIMENS

Steroids :

· For intubated croup dexamethasone 0.6 mg/kg i.v. then prednisolone 1 mg/kg 12 hourly nasogastrically.

· GOS regime for extubation Stridor and prophylaxis; dexamethasone 0.25 mg/kg i.v. followed by 0.1 mg/kg i.v. 6 hourly doses.

Nebulised Adrenaline:

· 0.4 ml/kg 1:1000 adrenaline maximum 5 ml

· ECG monitoring essential

· Temporarily discontinue if heart rate > 180

· May be repeated after 30 minutes if necessary³

CHOANAL ATRESIA

Choanal atresia may be unilateral or bilateral

Bilateral atresia presents with respiratory distress in the neonatal period as neonates are obligate nose breathers.

Immediate management involves taping an oropharyngeal airway in position and passing a nasogastric feeding tube.

40% of affected infants have other anomalies especially the CHARGE* association in which congenital heart defects are common.

Diagnosis is confirmed by failure to pass nasogastric tube.

Investigations: CT scan + investigation of associated defects.

Management: surgical correction with placement of nasal stents for 6-8 weeks

Usual anaesthetic considerations for neonatal surgery. Surgery requires a mouth gag which may obstruct small RAE tubes.

*CHARGE (colobomata, congenital heart disease, choanal atresia, retardation, hypogonadism, ear anomalies/deafness)

PIERRE ROBIN ANOMALIES

- Micrognathia-underdevelopment of the mandible
- Relative macroglossia
- Cleft palate

Airway obstruction may occur if severe, especially in the supine position and particularly after cleft palate repair. Improves with age.

Management; prone positioning, naopharyngeal airway, occasionally tracheostomy

AIRWAY AND INTUBATION PROBLEMS IN PAEDIATRIC SYNDROMES

There are a very large number of syndromes, some are very rare, which may cause difficulty with airway management during anaesthesia. The possibility of problems should always be considered in syndromic children and a reference text consulted if necessary.

The following problems may be encountered:

- Airway obstruction during induction and emergence
 - Difficulty with mask fit
 - Inability to visualize the glottis
 - Instability of the cervical spine
 - Abnormalities of the larynx eg subglottic stenosis that prevent passage of tracheal tube

Pre-operatively the patient should be examined and assessed for:

- Evidence of airway obstruction including stridor, snoring and features of sleep apnoea
- Deformity of the face especially micrognathia
- Restricted mouth opening
- Intra-oral abnormalities; infiltration, masses and enlarged tongue
- Restricted neck movements and instability of the neck

Previous anaesthesia records should be examined

EXAMPLES

Abnormalities	Problems	Examples
Midface abnormalities	difficult mask fit obstruction occasionally difficulty in visualising larynx	Apert's Crouzon's
micrognathia	obstruction difficulty in visualizing larynx	Pierre Robin Treacher Collins Goldenhar
large tongue	obstruction difficulty visualizing larynx	Beckwith-weidemann Down;s**
oral masses and infiltration	obstruction difficulty visualizing larynx	cystic hygoma mucopolysaccharidoses e.g Hurler's*
limited neck movement	difficulty visualizing larynx	Klippel-Feil juvenile chronic arthritis
unstable neck	difficulty viewing larynx with neck in neutral position	mucopolysaccharidoses e.g Hurler's*, Morquio's

** Down's is also associated with a small subglottis, and increased risk of post-exubation stridor and atlanto-axial instability

Hurler's is also associated with cardiac dysfunction

NOTES ON MANAGEMENT

Management in children differs from adult practice in that awake intubation is far from ideal except in neonotes.

The patients should be carefully assessed, the anaesthetic approach planned and equipment prepared. (selection of mask, airways, tracheal tubes, bougies and tracheostomy set + an expert ENT surgeon should be considered)

Premedication with atropine is desirable to dry up the secretions.

Inhalational induction with halothane in oxygen is usually preferred. CPAP, oropharyngeal/ nasopharyngeal airways and LMAs may be helpful in deepening anaesthesia. Relaxants should only be used if face mask ventilation is possible.

If any part of the glottis is visible, intubation may be possible using a bougie or introducer. The larynx is far

more mobile than in adults and firm cricoid push may be helpful.

Unstable necks must be held in a neutral position .

Fibreoptic bronchoscopes that take a 4.5 mm tube are available. An Olympus 2.2 mm scope (without suction port) is also manufactured but requires considerable practice if it is to be used successfully (the usual problem is passing the tube and not visualising the larynx).

Tracheostomy for airway problems is possible without intubation using an LMA or facemask. Infiltration with local anaesthetic by the surgeon is helpful in these circumstances.

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