Great Ormond Street Hospital for Children NHS Trust

12 - Airway Management and Chest drains

Author: Daniel Lutman 2004
Updated: Quen Mok, November 2006; Andy Petros and Sarfaraz Rahiman Nov 2010;

Associated clinical guidelines/protocols:

- Tracheostomy guidelines
- Management Difficult Airway
- Chest Drains
- Melbourne Strapping / ETT secure

Fundamental Knowledge:
List of topics relevant to PIC that will have been covered in membership examinations. They will not be repeated here.

Anatomy:

- Upper airway anatomy, innervation and blood supply.

Information for Year 1 ITU Training (basic):

Year 1 ITU curriculum
Airway skills:

- Clinical assessment of airway & recognition of potentially difficult airway.
- Methods of maintaining a clear airway and use of airway adjuncts:
- Indications for tracheal intubation
- Safe intubation technique & induction of anaesthesia
- Rapid sequence intubation.
- Causes of regurgitation and vomiting: prevention and management of pulmonary aspiration
- Difficult and failed intubation drill
- Detection and management of pneumothorax (simple and tension); insertion and safe management of chest drains

Curriculum Notes for Year 1:

Airway skills:
This is a practical subject that requires supervised practice and experience, and cannot be learnt by reading alone. There are several anatomic and physiologic features in infants and children that may impact advanced airway management. (1)

- Prominent occiput – causes varying degrees of neck flexion
- Large tongue – may impede visualization during direct laryngoscopy
- Larger tonsils and adenoids – obstruction; bleeding
- Superior laryngeal position – direct visualization more challenging
- Weaker hyoepiglottic ligament – Macintosh may not effectively elevate the epiglottis
- Large, floppy epiglottis
- Shorter and narrower trachea — predisposes to right mainstem bronchus intubation or inadvertent extubation

- Funnel-shaped airway
- Compliant chest wall - more likely to experience respiratory muscle fatigue, atelectasis and respiratory failure
- Lower functional residual capacity and Higher oxygen metabolism - heightened need for preoxygenation

Clinical assessment of the airway and recognition of potentially difficult airway:
The classic papers grading the difficulty are referenced and attempts to predict difficulty are discussed in the chapter by Hagberg and Ghatge [2]. Unfortunately a difficult airway is often not identified until laryngoscopy is performed, and a previous history of difficult airway management is the best predictor that this difficulty would recur. It is therefore important to clearly document a difficult intubation.

Assessment begins with a previous and current history (3). Various congenital syndromes and acquired conditions are associated with the difficult airway, hence this problem may be more of an issue with the GOS population.

- Congenital (Pierre-Robin syndrome, Treacher-Collins syndrome, Goldenhar's syndrome, Down's syndrome, etc)
- Infections (Laryngeal oedema, Croup, Oral or retropharyngeal abscess, Ludwig's angina)
- Arthritis (Temporomandibular joint ankylosis, restricted mobility of cervical spine)
- Tumors: Cystic hygroma, Malignant tumors,
- Trauma: Facial injury, cervical spine injury, Acute burns
- Obesity

Cormack-Lehane grading of direct laryngoscopy [4]

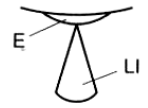
Original Cormack-Lehane system	I Full view of the glottis	II Partial view of the glottis or arytenoids		III Only epiglottis visible	IV Neither glottis nor epiglottis visible
View at laryngoscopy					
Modified system Cormack-Lehane	I As for original Cormack-Lehane above	IIa Partial view of the glottis	IIb Arytenoids or posterior part of the vocal cords only just visible	III As for original Cormack-Lehane above	IV As for original Cormack-Lehane above

Figure 8-1. Cormack-Lehane original grading system compared with a modified Cormack-Lehane system (MCLS). E = epiglottis; LI = laryngeal inlet. *Reproduced with permission from Yentis SM, Lee DJH: Evaluation of an improved scoring system for the grading of direct laryngscopy.* Anesthesia *1998; 82: 1197-1204.*

L Look externally
Look at the patient externally for characteristics that are known to cause difficult laryngoscopy, intubation or ventilation.

E Evaluate the 3-3-2 rule
In order to allow alignment of the pharyngeal, laryngeal and oral axes and therefore simple intubation, the following relationships should be observed. The distance between the patient's incisor teeth should be at least 3 finger breadths (3), the distance between the hyoid bone and the chin should be at least 3 finger breadths (3), and the distance between the thyroid notch and the floor of the mouth should be at least 2 finger breadths (2).

1 = Inter-incisor distance in fingers.
2 = Hyoid mental distance in fingers.
3 = Thyroid to floor of mouth in fingers.

M Mallampati
The hypopharynx should be visualized adequately. This has been done traditionally by assessing the Mallampati classification. The patient is sat upright, told to open the mouth fully and protrude the tongue as far as possible. The examiner then looks into the mouth with a light torch to assess the degree of hypopharynx visible. In the case of a supine patient, Mallampati score can be estimated by getting the patient to open the mouth fully and protrude the tongue and a laryngoscopy light can be shone into the hypopharynx from above.


Class I: soft palate, uvula, fauces, pillars visible


Class II: soft palate, uvula, fauces visible


Class III: soft palate, base of uvula visible


Class IV: hard palate only visible

O Obstruction?
Any condition that can cause obstruction of the airway will make laryngoscopy and ventilation difficult. Such conditions are epiglottis, peritonsillar abscesses and trauma.

N Neck mobility
This is a vital requirement for successful intubation. It can be assessed easily by getting the patient to place their chin down onto their chest and then to extend their neck so they are looking towards the ceiling. Patients in hard collar neck immobilization obviously have no neck movement are therefore harder to intubate.

Fig 1. The LEMON airway assessment method (5)

Maintaining a clear airway and airway adjuncts:

See relevant sections in APLS manual and LMA instruction manual.

Indications for intubation:

1. Anaesthetic indications
    a. Restricted access eg prone or head and neck surgery
    b. Ventilation required eg long surgery, thoracic or cardiac surgery
    c. Protection against tracheal soiling eg aspiration, oral surgery
    d. Airway obstruction
    e. Muscle relaxation required eg abdominal surgery
2. Non Anaesthetic indications
    a. Cardiopulmonary resuscitation
    b. Respiratory failure
    c. Airway protection eg in coma, uncontrolled seizures impaired airway reflexes or obstructed airway
    d. To allow aspiration of sputum/secretions

e. Control of PaCO2 in head injury patients
f. Investigations (e.g. bronchoscopy, CT, MRI)
g. Transport of a sick child.
h. Haemodynamic instability due to septic or cardiogenic shock

Safe intubation technique and induction of anaesthesia:
It is our unit policy to have 2 people present at all intubations on the ICU, even if one is experienced, in case of difficulties.

- EQUIPMENT:
  - Endotracheal tubes - ET tubes that are a half size above and below the estimated size for age must also be available. The endotracheal size and length can be estimated using the following table and formula taken from 'Drug Doses by Frank Shann 13th Ed 2005'. Although it has been traditionally taught that only uncuffed ETTs should be used for paediatric patients under 8 years of age, recent literature has shown that the modern low-pressure high-volume cuffed tubes can be used safely without an increased rate of complications [6,7]. It is important to monitor cuff pressures meticulously. Cuffed ET tube may be used in children with severe lung disease who may require high ventilator pressures; preferable for children at risk for aspiration. If a cuffed endotracheal tube is selected the formula predicted size is reduced by half a millimeter.

		Endotracheal tube				
Age	Wt kg	Int Dia mm	Ext Dia mm*	At Lip cm	At Nose cm	Sucker FG
Newborn	<0.7	2.0	2.9	5.0	6	6
Newborn	<1	2.5+	3.6	5.5	7	6
Newborn	1.0	3.0+	4.3	6	7.5	7
Newborn	2.0	3.0+	4.3	7	9	7
Newborn	3.0	3.0+	4.3	8.5	10.5	7
Newborn	3.5	3.5+	4.9	9	11	8
3 month	6.0	3.5	4.9	10	12	8
1 year	10	4.0	5.6	11	14	8
2 year	12	4.5	6.2	12	15	8
3 year	14	4.5	6.2	13	16	8
4 year	16	5.0	6.9	14	17	10
6 year	20	5.5	7.5	15	19	10
8 year	24	6.0	8.2	16	20	10
10 year	30	6.5	8.9	17	21	12
12 year	38	7.0	9.5	18	22	12
14 year	50	7.5	10.2	19	23	12
Adult	60	8.0	10.8	20	24	12
Adult	70	9.0	12.1	21	25	12

* External diameter of Mallinckrodt tubes
\+ ETT: <1kg 2.5mm, 1-3.5kg 3.0mm, >3.5 3.5mm
ETT: size mm = 4 + age/4; length (cm) at lip = 12 + age/2, at nose = 15 + age/2

  - Stylet - to reinforce the rigidity of the ET tube.
  - Bougie
  - Laryngoscopes and blades – checked to be working
  - Confirmation device - qualitative or quantitative detection of end-tidal CO2. Successful intubation is confirmed by capnography, as no other method has proved to be as reliable. Capnography may be unreliable in cardiopulmonary arrest. A chest radiograph should be obtained as soon as possible to confirm that the tip of the ET tube is located one to three centimeters above the carina and below the thoracic inlet.

Rapid sequence intubation (RSI) (8):
The goal of RSI is to take a non-fasted patient in an emergency situation from the conscious to unconscious, neuromuscularly blocked state and to perform tracheal intubation without intervening positive pressure ventilation. The important thing to remember is the increased risk of aspiration, hence positive pressure ventilation or insertion of a nasogastric tube should be avoided until the airway is secured.

Steps for RSI:

- PREOXYGENATION — If breathing spontaneously - adequate preoxygenation can be achieved using a nonrebreathing mask for a minimum of three minutes. If a child is apneic, hypoxic, in respiratory failure, or has insufficient respiratory reserve bag-mask ventilation with small tidal volumes may be performed for several minutes to achieve adequate preoxygenation.
- PREPARATION — A rapid review of key aspects of the child's history, as well as a targeted physical examination helps identify conditions that affect the optimal choices of medications for pretreatment, sedation, paralysis, and postintubation management, as well as a contingency plan in the event of a failed intubation. In addition, equipment (Suction, Oxygen, Airway equipment and Monitoring equipment (oxygen saturation, heart rate, blood pressure, end-tidal carbon dioxide))
    - Allergies to medications
    - History of or concern for neuromuscular disease and/or Any condition that could result in hyperkalemia, such as an acute crush injury or renal failure — Succinylcholine can cause a clinically significant rise in serum potassium in patients with neuromuscular disease.
    - Family history suggestive of malignant hyperthermia with anesthetics — Use of succinylcholine is absolutely contraindicated
    - Previous difficult intubation
    - Noisy breathing, particularly in sleep, suggests some degree of anatomic upper airway obstruction (such as enlarged tonsils or tongue) that may interfere with laryngoscopy or bag-mask ventilation.
    - Cardiovascular status
    - Increased intracranial pressure, focal neurologic signs
    - Bronchospasm

- PRETREATMENT —
    - Atropine — 0.02 mg/kg (minimum 0.1 mg; maximum 0.5 mg) IV for all children younger than one year, for those less than five years of age receiving succinylcholine, and for children older than five years requiring a second dose of succinylcholine.
    - Lignocaine — 1 mg/kg IV in raised intracranial pressure.
    - Opioids — usually fentanyl dose??
    - Defasciculating agents — Defasciculating agents (eg, rocuronium or vecuronium at one-tenth of the paralyzing dose) are not routinely recommended for children receiving succinylcholine.
- SEDATION AND PARALYSIS — The two essential medications used in rapid sequence intubation (RSI) are a sedative and a paralytic. The reader is referred elsewhere for profiles of Sedative and paralytic agents.
- PROTECTION— Protection during RSI refers to protecting the airway by preventing regurgitation of gastric contents and aspiration. This is accomplished with cricoid pressure and by avoiding bag-mask ventilation.
- POSITIONING —
    - To align the pharyngeal and tracheal axes, the neck is flexed forward on the shoulders, such that the external auditory canal is anterior to the shoulder. This may be accomplished in children by placing a towel or roll under the occiput. In infants, because of a prominent occiput, the towel must be placed under the shoulders to achieve this position. To align the oral axis with the pharyngeal and tracheal axes, the head is then extended on the neck, such that the nose and mouth are pointing toward the ceiling.
    - For children with suspected injury of the cervical spine, positioning must be accomplished without moving the neck. In-line manual stabilization must be maintained.
- PLACEMENT, WITH CONFIRMATION — Once adequate muscle relaxation is confirmed, laryngoscopy can be performed with careful attention to proper technique. After the tracheal tube has been placed and stylet removed, tube placement must be confirmed. Confirmation includes primary methods (such as auscultation for breath sounds over lung fields and stomach, the appearance of mist inside the tracheal tube,

and symmetric chest rise with positive pressure ventilation) as well as confirmation with detection of end-tidal carbon dioxide.
- POSTINTUBATION MANAGEMENT — Following placement and confirmation, the tracheal tube should be appropriately secured and a chest radiograph obtained to document proper placement and evaluate pulmonary status. Other issues that must be addressed include monitoring for complications related to the procedure and continuing sedation and paralysis.

CATS Clinical Guidelines 2006
Induction of anaesthesia

Notes on Anaesthetic Drug Management

General Aspects
Note that administering a general anaesthetic in an unfamiliar environment (ie a referring hospital) should be a two-doctor procedure using a local anaesthetist with appropriate skill. This enables rapid access to local resources in case of difficulty. If difficulty is anticipated or where conditions are not ideal, the following may be necessary, depending on time available:

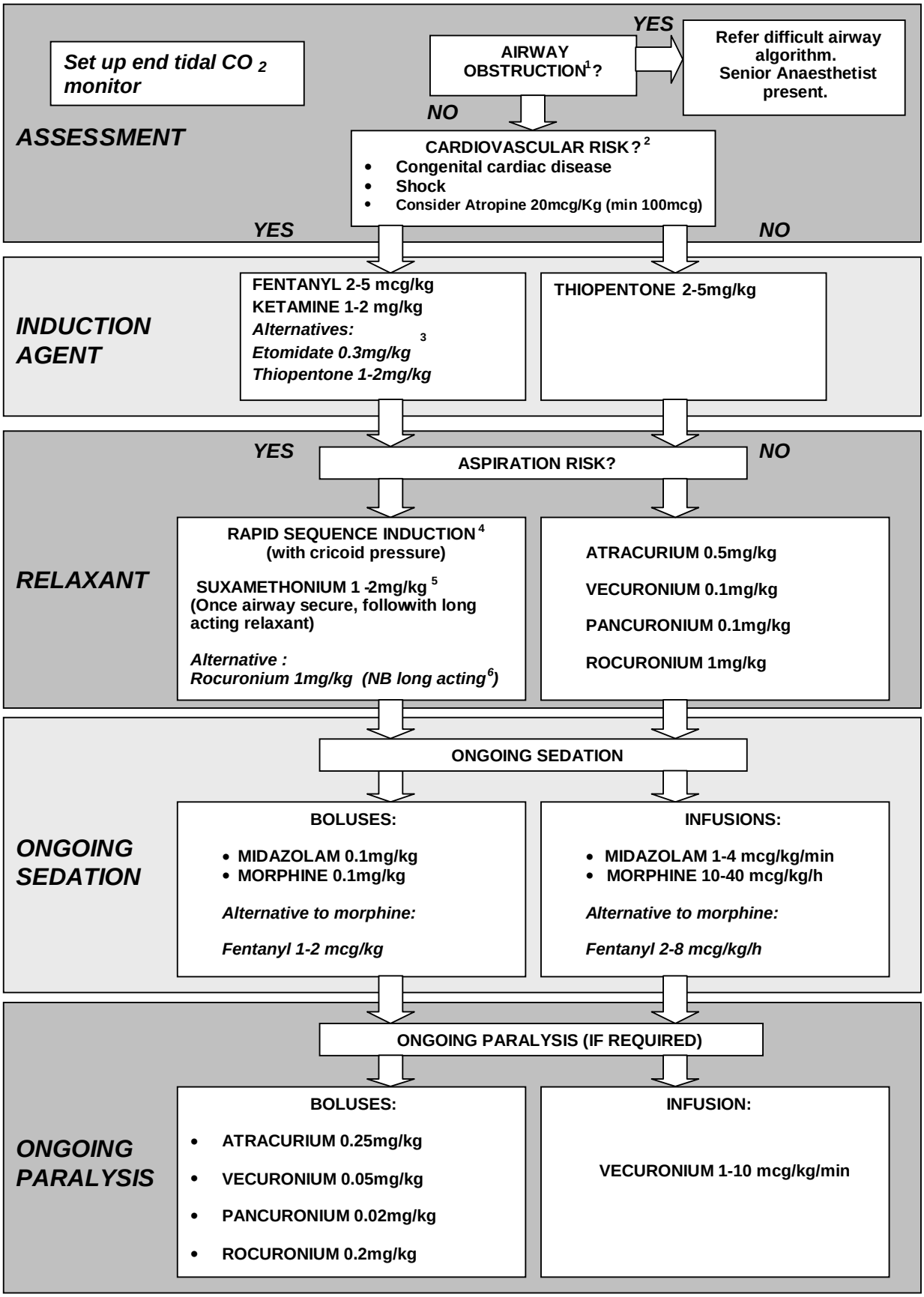
- The presence of a consultant anaesthetist from the referring hospital especially where airway obstruction is present.
- Moving the child to an anaesthetic room where more equipment may be to hand, as well as an operating department practitioner (ODP).

Approach all intubations with caution as it is impossible to exclude difficulty by examination

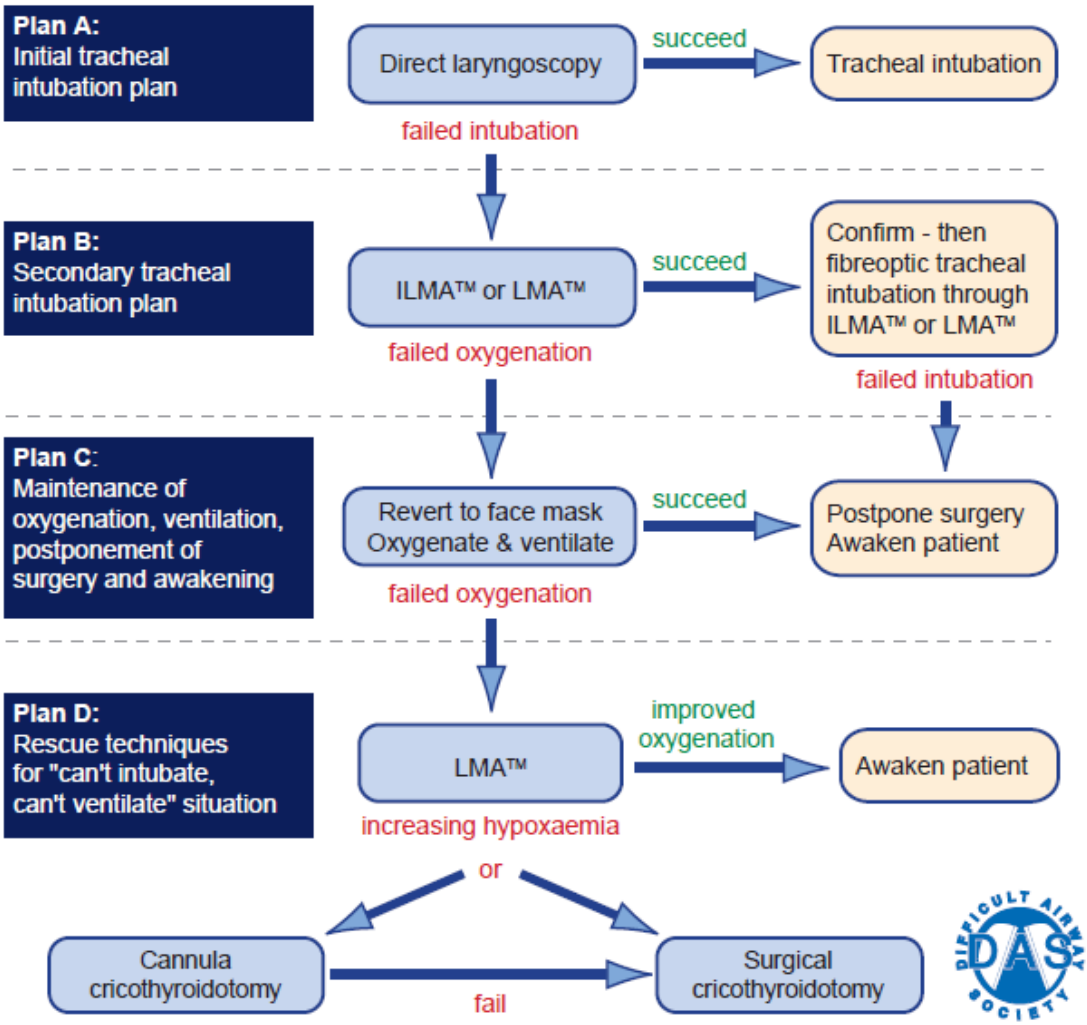
Assessment:
Management of the difficult airway requires senior anaesthetic and ENT assistance. In general an inhalational induction is favoured over intravenous induction. *Inhalational agents and anaesthetic machines should only be used by doctors trained in their use.*

Induction Agent:
Fentanyl or Ketamine are the agents of choice for the cardiovascularly unstable patient and may be used in all age groups. Etomidate use has become controversial in sepsis (Anaesthesia. 2005 Aug;60(8):737-40, Chest; Mar 2005; 127,3, Emerg. Med. J.2004;21;655-659) as it causes adrenal suppression. In cases of shock consider the use of physiologic steroid replacement eg.Hydrocortisone 1mg/kg 6 hourly iv (non-stressed physiological replacement is 0.2mg/Kg 8 hourly iv). Both thiopentone and etomidate reduce intracranial pressure. Ketamine increases intracranial pressure and should not be used if intracranial pressure is a clinical problem. For the unstable neonate an opiate-only technique may be used in which case fentanyl rather than morphine should be used due to its rapid action.

Relaxant:
Rapid sequence induction (RSI) involves preoxygenation, administering induction agent then relaxant in precalculated doses in rapid succession followed by application of cricoid pressure. The airway is then secured after onset of the muscle relaxant without mask ventilation. RSI may be practically difficult in small children and neonates owing to desaturation before full muscle relaxation. Suxamethonium is the RSI relaxant of choice. Its onset of action in 30 seconds is superior to all non-depolarising relaxants. It should not be used in patients with - hyperkalaemia, muscular dystrophy or myotonia, suspected or confirmed malignant hyperpyrexia, or 24 hours after major burn or spinal cord injury – owing to exaggerated hyperkalaemic response. In these circumstances rocuronium is an alternative if RSI is required – its onset of action is 45 to 60 seconds. Its long duration of action (40 minutes +) poses a problem if the airway cannot be secured.



Difficult and failed intubation drill (10):
The latest management guideline is in the Difficult Airway Society guidelines published in Anaesthesia [10] or their website. Although this is written for adults, the principles apply to our paediatric population, and is essential reading. Make sure that a difficult intubation is well documented in the patient notes.



Most intubations in PICU are because of oxygenation and ventilation problems and hence Plan C may not be entirely appropriate for PICU. More senior Anaesthetic and ENT help should be sought as available and child should be shifted to theatres for intubation or other procedures if time permits.

Detection and management of pneumothorax (simple and tension); insertion and safe management of chest drains (11)

Examination findings:
Increased respiratory distress.
Ipsilateral reduced chest expansion, reduced breath sounds, resonant to percussion
Subcutaneous emphysema
Hamman's sign
Mediastinal shift and tracheal displacement to the contralateral side.
In infants a sudden progressive abdominal distension may be noticed if a right sided pneumothorax causes the liver to displace downwards

Increasing airway pressures on volume control
Reducing tidal volumes on pressure control
High PaCO2

CXR may demonstrate rim of pleural gas or subcutaneous emphysema.
Anterior air on a supine film may be difficult to spot.
A change in diaphragm contour (flattening) may indicate a tension pneumothorax

Entonox is relatively contraindicated in pneumothorax as the nitrous oxide rapidly diffuses into the trapped gas.

Simple aspiration is less likely to succeed in secondary pneumothoraces. Traumatic pneumothorax or a pneumothorax in a ventilated patient should have an intercostal drain inserted. A tension pneumothorax may quickly progress to cardiorespiratory arrest, hence must be drained. There is no evidence that large tubes are any better than small tubes, although it may be necessary to replace a small chest drain with a larger one if there is persistent air leak. Suction may be added if there is persistent air leak or failure of the lung to re-expand. High volume low pressure (-10 to -20 cmH2O) suction systems are recommended.

Early referral to thoracic surgeons should be considered in persistent air leaks. Chemical pleurodesis can control difficult or recurrent air leak but should only be attempted if patient is unable to undergo surgery. Open thoracotomy and pleurectomy remains the procedure with the lowest recurrence rate but VATS (video assisted thoracoscopic surgery), pleural abrasion and surgical talc pleurodesis are all effective alternative strategies.

Other sources of information:

APLS manual

LMA instruction manual. The laryngeal mask company limited.

ASA Task force Guidelines for management of the difficult airway

Websites:

Information about capnography can be found on www.capnography.com

Difficult Airway Society guidelines for management of the unanticipated difficult intubation from the DAS website www.das.uk.com although this is written for adult patients

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12. *Henry M, Arnold T, Harvey J, on behalf of the BTS pleural disease group. BTS guidelines for the management of spontaneous pneumothorax. Thorax 2003;58 (suppl II): ii39-ii52*

Information for Year 2 ITU Training (advanced):

Year 2 ITU curriculum
Airway skills:

- Gas induction: indications, method and limitations
- Airway management in special circumstances; head & cervical spine injury, upper airway obstruction (croup & epiglottitis),
- Management of the unprotected airway.
- Tracheostomy: indications, contraindications, complications and management.
- Cricothyroidotomy
- Detection, aetiology and management of pleural effusions, empyema and chylothoraces

Curriculum Notes for Year 2:

Gas induction: indications, method and limitations

Inhalational induction is used in the situation where there is upper airway obstruction and it is anticipated that intubation may be difficult as spontaneous respiration is maintained. Alveolar (and hence blood) levels are easily controlled by adjusting inspired concentration of the inhalational agent. If the airway cannot be secured, at least the child will awaken when the volatile agent is discontinued. This should only be used by practitioners trained in the use of the anaesthetic machine. Refer to A to Z of Anaesthesia and Intensive Care for properties and undesirable effects of the different volatile agents.

Airway management in special circumstances:
Head & Cervical spine injury:

- The bougie is a useful adjunct in the patient with an injured cervical spine that facilitates intubation despite a sub-optimal view of the larynx.
- The Miller blades have the theoretical advantage of reducing the force during laryngoscopy; however, in practice this has not been shown to reduce movement of the neck. The levering laryngoscope and Bullard laryngoscope may be useful in experienced hands.

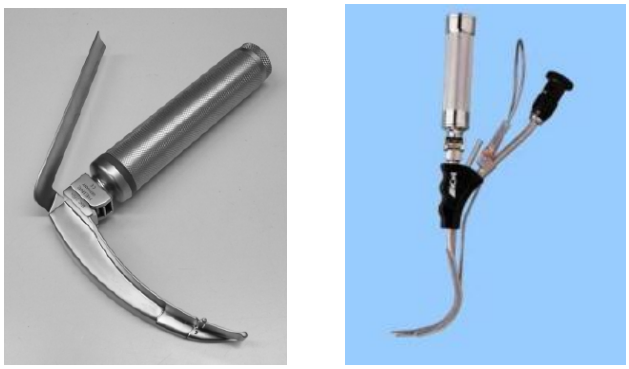

Fig 2: Levering laryngoscope and Bullard laryngoscope

- Cricoid pressure is important in the trauma patient since there may be a full stomach. The technique also improves the view at laryngoscopy with pressure applied backwards, upwards and to the right (BURP).
- Cervical spine immobilization: Rigid collars can make laryngoscopy more difficult, and therefore, should be removed before direct laryngoscopy is performed and Manual in Line Stabilization applied. If tracheal intubation is proving difficult, it may become necessary to reduce the grip as securing the airway is priority.
- Insertion of an LMA is only marginally more difficult than usual with C Spine immobilisation.
- Cricothyrotomy for 'can't intubate, can't ventilate' scenario.

Upper airway obstruction:

- Early involvement of the ENT and anaesthetic teams is important for any child who may require intubation. The child should be breathing high inspired oxygen, kept calm and allowed to adopt a comfortable position. An airway strategy should be pre-formulated by senior ENT and anaesthetic staff and equipment should be available.
- Generally, the primary plan is to establish a surgical plane of anaesthesia with an inhalational agent. Direct laryngoscopy is attempted only when the child is deeply anaesthetized. Muscle relaxants should not be used until the airway is secure.

Burns and Inhalational Injury:

- With burns involving the airway, oropharynx, or related structures, early endotracheal intubation is indicated. The edema that ensues will rapidly create a difficult intubation scenario and make securing a definitive airway a challenge.
- Early in the course of events, with appropriate induction, muscle relaxation, and cricoid pressure, direct laryngoscopy usually provides an effective mode of performing an orotracheal intubation. As edema worsens and signs of upper airway obstruction appear, endotracheal intubation becomes more difficult. At this point fiberoptic bronchoscopic-assisted intubation may be necessary.
- Endotracheal tubes should not be cut in burns patients as the tube tends to lift out with the strapping as the burned tissues swell.
- Another source of complication includes accidental extubation with head turning or mishaps on transport. Resecuring the airway in these scenarios can be extremely difficult. Tracheostomy has been suggested as a means to decrease airway-related morbidity.

Tracheostomy: indications, contraindications, complications and management

The indications for tracheostomies in children have changed in the last 30 years from treatment of acute infections of the airway to management of prolonged ventilation for neuromuscular or respiratory problems [11]. Tracheostomy is also performed for congenital and acquired airway abnormalities, as well as for craniofacial syndromes. It is associated with significant morbidity and mortality especially in infants and young child [12]. Early complications include air leaks and haemorrhage, while misplacement, accidental decannulation and tube obstruction can occur anytime and can result in death. Children who have been tracheostomised for more than a week have a delay in speech acquisition, affecting both receptive and exprressive communication. See tracheostomy guidelines for management.

Cricothyroidotomy

See APLS manual

Detection, aetiology and management of pleural effusions, empyema and chylothoraces

Pleural effusions are usually secondary to acute bacterial infections, with pneumococcus emerging as the predominant pathogen in childhood empyema. Other pathogens (Staph

aureus, Mycoplasma, Mycobacteria and viruses) can also cause pleural effusions. Rarely this may be the presenting sign of a malignancy, HLH or a connective tissue disorder.

Ultrasound scan is useful in identifying loculations and to guide thoracocentesis or drain placement. Conservative treatment with intravenous anitbiotics and simple drainage may be effective in small parapneumonic effusions. Intrapleural fibrinolytics are recommended for any complicated parapneumonic effusion (thick fluid with loculations) or empyema (overt pus). There is no evidence that any of the 3 fibrinnolytics are more effective than the others, but only urokinase has been studied in a RCT in children, and is therefore recommended. Surgical treatment using VATS should be considered if there is persisting sepsis in association with a persistent effusion. However a formal thoracotomy and decortication may be required for organised empyema. See algorithm below taken from the BTS guidelines [13]

A chylothorax is more likely following trauma or cardiac surgery due to involvement of the thoracic duct. The thoracic duct transports intestinal and skeletal lymph, as well as the majority of proteins and ingested fats and the bulk of lymphocytes, back into the circulation. This would therefore lead to hypoalbuminemia, hypogammaglobulinemia and lymphopenia, with an increased risk of infection. Conservative therapy would include medium chain triglyceride feeds and octreotide, or enteral rest with parenteral nutrition, to reduce chyle production. Albumin and immunoglobulin infusions would be necessary to replace ongoing losses. [14]. Surgical therapies include pleuroperitoneal shunts to recycle the chyle, pleurodesis or thoracoscopic repair of the thoracic duct. Biochemical analyses of the effusion may help identify the cause [15]

BTS guidelines for the management of pleural infection in children

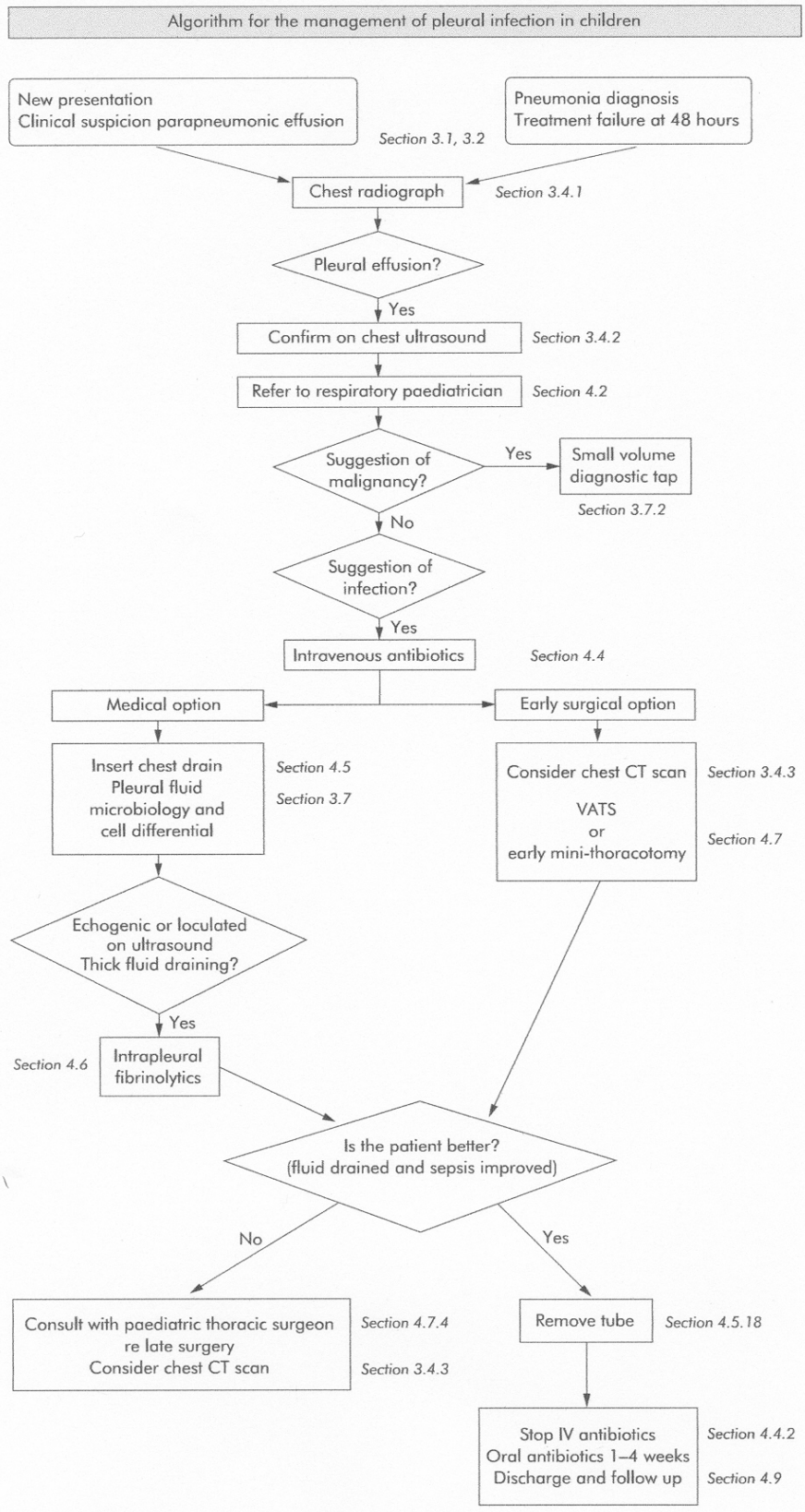

Figure 1 Algorithm for the management of pleural infection in children.

Balfour-Lynn IM et al. BTS guidelines for the management of pleural infection in children. Thorax 2005

Other sources of information:

APLS manual

Anesthesia and Intensive Care A-Z by Yentis, Hirsch and Smith. Butterworth Heinemann

Websites

http://www.virtual-anaesthesia-textbook.com

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