Airway management
Skills and techniques

Update 2011 (pdf)

Module Authors (Update 2011)

Gavin LAVERY
Dept of Clinical Anaesthesia, Royal Victoria Hospital, Belfast, Northern Ireland

Brian McCLOSKEY
Regional Intensive Care, Royal Victoria Hospital, Belfast, Northern Ireland

Eamon McCoy
Royal Victoria Hospital, Belfast, Northern Ireland

Module Authors (first edition)

Gavin LAVERY
Dept of Clinical Anaesthesia, Royal Victoria Hospital, Belfast, Northern Ireland

Brian McCLOSKEY
Regional Intensive Care, Royal Victoria Hospital, Belfast, Northern Ireland

Module Reviewers
Per Nellgård, Janice Zimmerman

Section Editor
Anders Larsson
# Airway management
## Update 2011

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
<th>Institution/Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Editor-in-Chief</td>
<td>Dermot Phelan</td>
<td>Intensive Care Dept, Mater Hospital/University College Dublin, Ireland</td>
</tr>
<tr>
<td>Deputy Editor-in-Chief</td>
<td>Francesca Rubulotta</td>
<td>Imperial College, Charing Cross Hospital, London, UK</td>
</tr>
<tr>
<td>Medical Copy-editor</td>
<td>Charles Hinds</td>
<td>Barts and The London School of Medicine and Dentistry</td>
</tr>
<tr>
<td>Self-assessment Author</td>
<td>Hans Flaatten</td>
<td>Bergen, Norway</td>
</tr>
<tr>
<td>Editorial Manager</td>
<td>Kathleen Brown</td>
<td>Triwords Limited, Tayport, UK</td>
</tr>
<tr>
<td>Business Manager</td>
<td>Estelle Flament</td>
<td>ESICM, Brussels, Belgium</td>
</tr>
<tr>
<td>Chair of Education and Training Committee</td>
<td>Marco Maggiorini</td>
<td>Zurich, Switzerland</td>
</tr>
</tbody>
</table>

### PACT Editorial Board

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Editor-in-Chief</td>
<td>Dermot Phelan</td>
</tr>
<tr>
<td>Deputy Editor-in-Chief</td>
<td>Francesca Rubulotta</td>
</tr>
<tr>
<td>Respiratory failure</td>
<td>Anders Larsson</td>
</tr>
<tr>
<td>Cardiovascular critical care</td>
<td>Jan Poelaert/Marco Maggiorini</td>
</tr>
<tr>
<td>Neuro-critical care and Emergency medicine</td>
<td>Mauro Oddo</td>
</tr>
<tr>
<td>Critical Care informatics, management and outcome</td>
<td>Carl Waldmann</td>
</tr>
<tr>
<td>Environmental hazards and Obstetric critical care</td>
<td>Janice Zimmerman</td>
</tr>
<tr>
<td>Infection/inflammation and Sepsis</td>
<td>Johan Groeneveld</td>
</tr>
<tr>
<td>Kidney Injury and Metabolism.</td>
<td>Charles Hinds</td>
</tr>
<tr>
<td>Abdomen and nutrition</td>
<td>Torsten Schröder</td>
</tr>
<tr>
<td>Peri-operative ICM/surgery and imaging</td>
<td>Graham Ramsay</td>
</tr>
<tr>
<td>Professional development and Ethics</td>
<td>Gavin Lavery</td>
</tr>
<tr>
<td>Education and assessment</td>
<td>Lia Fluit</td>
</tr>
<tr>
<td>Consultant to the PACT Board</td>
<td>Graham Ramsay</td>
</tr>
</tbody>
</table>

Copyright © 2011. European Society of Intensive Care Medicine. All rights reserved.
Airway management
Learning objectives:

After studying this module on Airway management, you should be able to:

1. Make a complete assessment of the airway
2. Explain indications, contraindications and techniques for different methods of securing the airway
3. Describe correct tracheal tube positioning and confirmation of tracheal tube placement
4. Identify techniques to deal with the anticipated and unanticipated difficult airway
5. Detail pitfalls in airway management.
Contents

Introduction ..................................................................................................................... 1

1. Assessment of airway ................................................................................................. 2
   Airway patency ........................................................................................................... 2
   Recognition of injuries to airway or other structures ............................................... 3
   Recognition of anatomic variations/abnormalities ...................................................... 4
   Protective reflexes ....................................................................................................... 6
   Respiratory drive ........................................................................................................ 7
   Inspired oxygen concentration ................................................................................. 8
   Identification of signs of hypoxaemia ....................................................................... 8
   Identification of dyspnoea .......................................................................................... 9

2. Airway interventions ................................................................................................... 10
   Patient positioning ..................................................................................................... 10
   Clearing the airway .................................................................................................... 11
   Triple airway manoeuvre .......................................................................................... 12
   Artificial airway .......................................................................................................... 12
      Oropharyngeal airway .............................................................................................. 12
      Nasopharyngeal airway ............................................................................................ 13
   Oxygenation and ventilation ..................................................................................... 14
      Variable flow face-mask ......................................................................................... 14
      Manual ventilation using a mask ........................................................................... 14
      Apnoeic oxygenation ............................................................................................... 15
   Tracheal intubation ..................................................................................................... 16
      Orotracheal intubation ............................................................................................. 17
      Nasotracheal intubation .......................................................................................... 20
   Fibre optic intubation ................................................................................................. 21
      Contraindications (All relative) ............................................................................. 22
      Advantages of fibre optic intubation ...................................................................... 22
      Conduct of fibre optic intubation ............................................................................ 22
   Laryngeal mask airway ............................................................................................... 24
      Developments of Laryngeal Mask Airway ............................................................. 25
      Intubating laryngeal mask airway .......................................................................... 25
   Oesophageal-tracheal double lumen device .............................................................. 26
   Cricothyroidotomy ..................................................................................................... 26
      Equipment ............................................................................................................... 27
      Seldinger technique ............................................................................................... 27
      Ventilation through the cricothyroidotomy ........................................................... 27
   Tracheostomy ............................................................................................................. 28
      Timing of tracheostomy: early versus late ............................................................. 29
      Percutaneous tracheostomy ................................................................................... 29
      Tracheostomy tubes ............................................................................................... 31

3. Recognition of effective ventilation ........................................................................... 32
   Correct tracheal tube positioning ............................................................................. 32
   Anatomy of the airways ............................................................................................. 32
   Confirmation of tracheal tube placement ................................................................... 32
   Visualising the tube passing into the trachea ........................................................... 33
   Chest wall movement on manual ventilation ............................................................ 33
   Presence of water vapour condensing on the tracheal tube (‘misting’) ..................... 33
   Auscultation of breath sounds .................................................................................. 33
   Compliance of the reservoir bag .............................................................................. 33
   End-tidal carbon dioxide .......................................................................................... 33
   Negative pressure devices ....................................................................................... 34
   Fibre optic confirmation ........................................................................................... 34
4. The difficult airway: algorithms & adjuncts to management .................................. 36
   Difficult airway guidelines .................................................................................... 36
   Difficult intubation ............................................................................................... 36
   Anticipated difficult intubation ............................................................................ 37
   Unanticipated difficult intubation ....................................................................... 39
   Failure to intubate and failure to ventilate ......................................................... 44
   Extubation of the difficult airway ....................................................................... 46
   Airway exchange catheter .................................................................................. 46

5. Pitfalls in airway management ............................................................................ 47
   Ineffective breathing despite artificial airway ..................................................... 47
   Ineffective manual mask ventilation despite artificial e.g. oropharyngeal airway .. 47
   One-sided intubation and ventilation .................................................................. 48
   Tube obstruction ................................................................................................... 49
      Tracheal tube obstruction ............................................................................... 49
      Tracheostomy tube obstruction ...................................................................... 50
   Tube displacement ............................................................................................... 51
      Tracheal tubes .................................................................................................. 51
      Tracheostomy tubes ....................................................................................... 51

Conclusion ............................................................................................................ 52
Self-assessment .................................................................................................... 53
Patient challenges ............................................................................................... 57
INTRODUCTION

Airway management is the first step in resuscitation of the critically ill patient. There are basic airway manoeuvres that can be learned quickly by medical and non-medical staff and advanced airway manoeuvres that require training and experience to be used appropriately. Airway management may be achieved simply by confirming the patient has an unobstructed airway and by supplying supplemental oxygen. Alternatively it may require complex interventions such as tracheal intubation, fibre optic techniques or the establishment of a surgical airway.

The clinician who takes care of the critically ill patient should have the ability to:

- Make a rapid and complete assessment of the airway
- Secure the airway by different methods
- Be familiar with algorithms for difficult airway management.

The sources below contain much useful information on airway anatomy, causes of airway obstruction and airway management. These references should be read before completion of Task 1.


1. **Assessment of Airway**

Assessment of the airway can be considered in four parts.

<table>
<thead>
<tr>
<th>Airway patency</th>
<th>Respiratory drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protective reflexes</td>
<td>Inspired O₂ concentration</td>
</tr>
</tbody>
</table>

- **Airway patency** – a partial or complete obstruction will compromise ventilation of the lungs and therefore gas exchange.
- **Protective reflexes** – these help maintain patency and will prevent aspiration of material into the lower (pulmonary) airways.
- **Respiratory drive** – a patent and secure airway is of no value if gas is not being exchanged between the exterior and the pulmonary alveoli.
- **Inspired oxygen concentration** – gas entering the pulmonary alveoli must have an adequate oxygen concentration.

**Airway patency**

Airway obstruction is most frequently due to reduced muscle tone allowing the tongue to fall backwards against the posterior pharyngeal wall thus blocking the airway. This often happens when an obtundated or anaesthetised patient is lying supine.

*©Janet Fong 2011; http://www.aic.cuhk.edu.hk/web8/Hi%2ores/Triple%2omanoeuvre1.jpg*

The table below lists other frequent causes of airway obstruction.

<table>
<thead>
<tr>
<th>Location</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oropharynx</td>
<td>Presence of blood</td>
</tr>
<tr>
<td></td>
<td>Presence of mucus</td>
</tr>
<tr>
<td></td>
<td>Presence of vomitus</td>
</tr>
<tr>
<td></td>
<td>Presence of foreign bodies</td>
</tr>
</tbody>
</table>
Upper airways | Oedema
---|---
Swelling | Inflammation of the tissues bordering the airway

**Anecdote** A 26-year-old man arrived in the Emergency Department having been in a house fire. His face and oral cavity showed heavy deposits of carbonaceous material. He was alert, able to speak in a hoarse voice and was moderately tachypnoeic. Ten minutes later he complained of difficulty breathing, had significant stridor and could not vocalise. After a further ten minutes he was drowsy, obtunded and in severe respiratory distress. It was decided to intubate the patient and this was achieved only with great difficulty due to almost complete airway obstruction secondary to oedema and inflammation of the epiglottis and larynx caused by thermal injury. Breathing difficulties in burn victims frequently require immediate tracheal intubation due to rapidly developing airway/glottic oedema.

See the current PACT module on Environmental hazards. A separate module on Burns Injury is in preparation.

See Task 4 Difficult airway algorithms and adjuncts to management.

Airway obstruction is difficult to describe but has a characteristic presentation. Noisy breathing (on inspiration termed stridor), poor expired airflow, retraction of soft tissues, increased respiratory distress and paradoxical 'rocking' movements of the thorax and abdomen occur. These resolve quickly if the obstruction is removed. In total airway obstruction there are no sounds of breathing due to complete lack of airflow through the larynx.

**Q. What is the difference between stridor and bronchospasm?**

A. Stridor is the term used to describe an inspiratory noise, which sounds similar to 'wheezing'. It is due to partial upper airway obstruction from any cause e.g. foreign body/tumour in airway or to conditions causing vocal cord oedema or paralysis. It is a very significant clinical sign and may herald total obstruction/respiratory arrest. Bronchospasm is predominantly an expiratory 'wheezing' sound associated with bronchial narrowing e.g. asthma, COPD or anaphylactoid reactions.

**Recognition of injuries to airway or other structures**

Trauma to the head and neck may have direct effects on the airway. Fractures or dislocation to the facial skeleton and mandible may cause immediate disruption to the structures of the naso- and oropharynx. Other complications may occur later during resuscitation of the trauma patient.
as a result of inflammation or soft tissue swelling and bleeding into the airway. Pulmonary aspiration of blood or dislodged teeth may occur.

Postoperative bleeding after operations to the neck (thyroid gland, carotid, larynx) may lead to compression or displacement of the airway and subsequent difficulty in intubation. Direct injury to the larynx is rare but may result in disruption of the laryngeal mechanism producing progressive hoarseness and subcutaneous emphysema. Tracheal intubation may make this situation worse and, if attempted, requires great care and skill.

In assessing the airway, always recognise the potential for cervical spine injuries. Inadvertent movement of the cervical spine may occur during airway manoeuvres. This should be avoided or at least minimised by choosing the best technique and by appropriate execution.

The references below will be helpful.


**Recognition of anatomic variations/abnormalities**

Difficulties in maintaining or securing a patent airway can often be anticipated by thorough inspection and investigation of the anatomy of the oropharynx, maxilla, mandible, dentition and neck. It is important to realise that while some of these signs are visible, some are only detectable by investigation.

The following anatomical features suggest airway difficulty or difficult intubation:

- Obesity
- Maxillary prognathia or prominent upper incisors
- Short muscular neck and/or limited neck flexion or head extension (rheumatoid arthritis, ankylosing spondilitis)
- Large breasts e.g. in advanced pregnancy
- Acromegaly
- High arched palate (Marfan syndrome)
- Oropharyngeal infections and tumours
- Cystic hygroma
- Thyro-mental distance: measured from the upper edge of the thyroid
cartilage to the chin with the head fully extended. A distance over 7 cm is usually associated with easy intubation. A distance less than 6 cm may predict a difficult intubation.

Inability to open mouth suggests potential airway difficulty:

- Masseter muscle spasm (dental abscess)
- Temporo-mandibular joint dysfunction
- Scarring – including post radiotherapy fibrosis
- Rheumatoid arthritis
- Facial burns
- Scleroderma
- Trismus
- Pierre Robin syndrome: characterised by an unusually small mandible (micrognathia), posterior displacement or retraction of the tongue, upper airway obstruction. Cleft palate present in the majority of patients.

Cervical immobility/abnormality might suggest a difficult intubation:

- Presence of cervical collar
- Ankylosis spondylitis
- Post radiotherapy fibrosis
- Cervical haematomas (thyroid or anterior cervical surgery)
- Klippel–Feil abnormalities of the cervical spine.

Basic airway management as well as tracheal intubation may be difficult or impossible without great expertise and/or special techniques. Some of these factors may be assessed using the Mallampati or Wilson Scores. Further details are available in the sources below.


http://www.faces-cranio.org

Such scores are of value in every situation when there is time for evaluation and to choose the technique of choice for airway management. Other work, (referenced below) has highlighted that all such assessments are useful but not foolproof. When airway difficulty occurs unexpectedly (an urgent/emergency situation), the use of a difficult airway algorithm (Task 4) should be mandatory.


Protective reflexes

Protective reflexes exist to safeguard a patent airway and to prevent foreign material entering the lower respiratory tract (pulmonary aspiration). The upper airway shares a common pathway with the upper gastrointestinal tract. These reflexes depend on the proper functioning of the epiglottis, false and true vocal cords and the sensory supply to the mucous membrane of the pharynx.

Q. What clinical situations/diagnoses are associated with partial or total loss of reflexes protecting patients from pulmonary aspiration?

A. Any cause of:
   - Decreased level of consciousness: intoxication, overdose, brain injury, brain-stem dysfunction, stroke, tumour, demyelination, polyneuritis.
   - Mechanical (motor) impairment of swallowing: pharyngeal tumour, pharyngeal pouch, polyneuritis.
   - Sensory impairment of pharynx/larynx: local anaesthesia, polyneuritis.

Patients who can swallow normally have intact airway reflexes. Normal speech makes absence of such reflexes unlikely but not impossible. If a patient tolerates an oropharyngeal airway (see later) without gagging then the protective reflexes are either absent or obtunded. The reference below will yield further detail on pharyngeal and laryngeal reflexes if required.


Patients with a decreased level of consciousness (LOC) should be assumed to have inadequate protective reflexes until proven otherwise.
Respiratory drive

Even a patent and protected airway will fail to ensure adequate oxygenation and excretion of carbon dioxide in the absence of adequate respiratory drive. Respiratory drive is controlled by the respiratory centre which acts to maintain pH (in the CSF) at 7.4. If arterial pCO₂ increases (for example by rebreathing of expired air containing CO₂) this reduces pH and results in an increase in minute volume – the volume of gas entering and leaving the lungs per minute – due to stimulation of the respiratory centre. This reverses the rise in CO₂ (negative feedback). This assumes that increased respiratory drive produces an increase in minute ventilation (increased respiratory rate and/or tidal volume per breath). This may not occur if respiratory mechanics are disturbed.

The mechanisms involved in the control of breathing and common factors which influence this system can be fully understood by reading the PACT modules on Mechanical ventilation and Respiratory failure.

Q. What factors influence minute volume in (a) a spontaneously breathing patient with multiple fractured ribs and (b) the same patient after initiation of positive pressure ventilation?

A. (a) Minute volume is the total volume of gas passing into/out of the lungs per minute, calculated by respiratory rate x tidal volume.

In this patient, both factors will be influenced by degree of pain/analgesia, respiratory depression due to narcotics (reduce respiratory rate) or other drugs, mechanical effects of fractured ribs, intercostal spasm and underlying lung injury (or pre-existing disease).

(b) Mainly respiratory rate and tidal volume (volume controlled) or inspiratory pressure (pressure controlled) settings on ventilator. Sometimes there may be additional minute ventilation due to spontaneous respiration by the patient (see above).

See the PACT module on Mechanical ventilation (glossary).

An objective and widely accepted measure of LOC is the Glasgow Coma Scale. A decreased LOC is due to widespread depression of neuronal activity and, not surprisingly, may be associated with depression of the respiratory centre and hence reduced respiratory drive. Opioids, sedatives and alcohol are potent respiratory centre depressants.

See the PACT module on Sedation and analgesia.


Ventilatory function and respiratory drive can be assessed by looking, listening and feeling. If a patient is breathing spontaneously, listening to the sounds and
feeling air movement while looking at the volume and frequency of thoracic movement gives an impression of airflow. This is the initial clinical technique for assessing the ventilatory function. It is quick, simple and easy but unreliable as a quantitative measure of tidal or minute volume.

Observing the nature of the movements of the thorax/abdomen and the respiratory rate is also part of assessing the adequacy of minute ventilation, as is the measurement of arterial pCO\(_2\) by blood gas analysis. End-tidal CO\(_2\) can often (but not always) be used as a real time measure of the adequacy of minute ventilation. If respiratory drive/minute ventilation is inadequate, respiratory support, usually in the form of positive pressure ventilation should be instituted.

**Inspired oxygen concentration**

When managing the airway, the aim is to produce the maximum oxygen tension possible in the alveoli. The balance between oxygen supply and demand is often unfavourably altered due to impaired cardiorespiratory function and increased metabolic demands in illness or after injury. Therefore high inspired oxygen concentrations are required to satisfy tissue oxygen demand, prevent tissue hypoxia and to prevent critical de-saturations.

See the PACT module on Respiratory monitoring.

A cuffed tracheal tube represents a sealed system and thus the oxygen concentration delivered to the tube will be the inspired concentration. Conversely, patients apparently receiving 100% oxygen via a face-mask are inspiring much less e.g. 40–60% O\(_2\). When breathing oxygen through a face-mask, entrainment of room air and dilution of the oxygen concentration occurs due to many factors including the rate of oxygen flow, the inspiratory flow rate and tidal volume generated by the patient and the ease of ingress of room air around the edges (or through holes) of the face-mask.

When wishing to deliver the maximum inspired oxygen concentration to a patient using a face-mask, the mask should be close fitting with a reservoir bag and no lateral openings. Oxygen flow should be 15 l/min. If 100% oxygen is delivered to such a system, the patient will be inspiring approximately 80–85% oxygen. Using an oxygen reservoir is also necessary when a patient is ventilated using a bag-valve-mask if entrainment of room air (and dilution of the inspired oxygen concentration) is to be avoided.

### Note

The oxygen mask used and the speed of oxygen flow are important factors in determining the concentration of oxygen delivered to the patient’s airway.

**Identification of signs of hypoxaemia**

Hypoxaemia, defined as reduced partial pressure of oxygen in arterial blood due to inadequate oxygenation, may result in (tissue) hypoxia and, potentially, cellular damage/death.
Hypoxaemia may cause widespread bluish discolouration of the mucous membranes and nail-beds termed central cyanosis. This is due to the presence of deoxy-haemoglobin in a concentration of at least 5 g/dl. Hypoxaemia may lead to agitation, confusion, drowsiness as well as signs of sympathetic overactivity and respiratory distress. If not corrected rapidly, it may lead to cardiac arrest, irreversible cerebral injury, organ dysfunction and death.

See the PACT module on Respiratory failure.

Note that a patient with significant anaemia may never exhibit cyanosis, while alive, despite severe hypoxia. With a low total haemoglobin it may not be possible to have as much as 5 g/dl in the deoxygenated form.

**Identification of dyspnoea**

Dyspnoea, breathlessness, respiratory distress and respiratory difficulty are closely related. Breathlessness can be considered as a subjective judgment – a symptom that may be defined as an inappropriate relationship between respiratory work and total body work. The other terms are more objective and may be present even when a patient denies being breathless. Clinically significant dyspnoea may be difficult to detect especially in patients with pre-existing respiratory disease and when it is evolving slowly.

**Q. What are the clinical signs of dyspnoea?**

A.

- Tachypnoea
- Inability to speak more than a few words between breaths
- Sweating/tachycardia/hypertension
- Cardiac dysrhythmia
- Agitation/refusal to lie down
- Use of accessory muscles
- Retraction of supraclavicular/suprasternal/intercostal tissues
- Pursing of lips/nasal flaring.

**Assess six hospital in-patients with chronic obstructive pulmonary disease for signs of dyspnoea and grade their severity of distress.**

**NOTE** The onset of hypoxaemia and respiratory difficulty may be gradual and is sometimes unsuspected until cardiorespiratory arrest is imminent. Beware of patients who appear confused, disorientated or ‘drunk’ – particularly if subsequently they become ‘quiet’.

[9]
2. AIRWAY INTERVENTIONS

The inability to establish a definitive airway may be the result of failure to optimise clinical conditions when performing airway manoeuvres. Inexperience and/or lack of skill on the part of the practitioner and lack of skilled assistance are important factors in scenarios in which airway problems are reported.

Common errors include:

- Poor patient positioning
- Failure to ensure appropriate assistance
- Faulty light source in laryngoscope/no alternative scope
- Failure to use a longer blade in appropriate patients
- Use of inappropriate tracheal tube (size or shape)
- Lack of immediate availability of airway adjuncts.


Kluger MT, Short TG. Aspiration during anaesthesia: a review of 133 cases from the Australian Anaesthetic Incident Monitoring Study (AIMS). Anaesthesia 1999; 54(1): 19–26. PMID 10209365


Kluger MT, Bullock MF. Recovery room incidents: a review of 419 reports from the Anaesthetic Incident Monitoring Study (AIMS). Anaesthesia 2002; 57(11): 1060–1066. PMID 12392453


Patient positioning

⚠️ When considering and performing any airway manoeuvres, you must ask: ‘Am I sure that this patient has a stable cervical spine’. If the answer is negative, you must use manual in-line immobilisation of the cervical spine during the manoeuvre which will require the help of a second person. This is most relevant to patients who have sustained significant trauma but may also be important in patients with severe cervical spine pathology e.g. rheumatoid arthritis, severe osteoporosis.

Correct patient positioning is essential to facilitate successful airway management. Elevating the head 7–10 cm with a pillow under the occiput and extending the atlanto-occipital joint should align the oral, pharyngeal, and
laryngeal axes to provide the best straight line from lips to glottis (sniffing position).


Lavery GG, McCloskey BV. The difficult airway in adult critical care. Crit Care Med 2008; 36(7): 2163–2173. PMID 18552680

**Clearing the airway**

Patients who are talking normally may be assumed to have a clear airway. The inability to speak normally, particularly in an obtunded patient, may be due to airway obstruction by the tongue or by material – liquid (saliva, blood, gastric contents) or solid (teeth, broken dentures, food) – in the posterior oropharynx and nasopharynx. Children may obstruct their airway with sweets or small toys in the mouth or further down the airway.

If possible, secretions should be cleared under direct vision with a laryngoscope using a suction device. If oral suction is not possible, the nasopharyngeal route should be used. The finger sweep should be reserved for patients without an intact gag reflex.

**Anecdote** A child was admitted to the Resuscitation Room after a road traffic accident. The child had been a back seat passenger and was deeply cyanosed and had obstructed breathing. Use of the triple airway manoeuvre (see below), suctioning of the pharynx and an oropharyngeal airway had no beneficial effect. At laryngoscopy the vocal cords were easily seen but an orotracheal tube could not be inserted into the trachea. During attempts to perform a tracheostomy, the child suffered a cardiac arrest and could not be resuscitated. At post-mortem a small plastic toy was found lodged in the airway at the level of the cricoid ring.

**Note** The indications and contraindications for the various airway manoeuvres and associated equipment/techniques are discussed briefly below.
Triple airway manoeuvre

This manoeuvre is often useful in situations where maintaining a patent airway using neck extension alone has failed or is not recommended, particularly in the obtunded patient. The triple airway manoeuvre employs head tilt (neck extension), jaw thrust and mouth opening. However, it will likely be ineffective when airway obstruction is caused by a foreign body.

The operator should stand behind and above the patient's head and

- Extend the neck by placing the hands on either side of the mandible
- Elevate the mandible with the fingers of both hands, thus lifting the base of the tongue away from the glottic opening
- Open the mouth with the thumbs or forefingers.

©Janet Fong 2011;
http://www.aic.cuhk.edu.hk/web8/Hi%2ores/Triple%20manoeuvre3.jpg

Do not use neck extension in situations of actual or potential cervical spine injury. Both the jaw thrust and chin lift may also cause distraction of cervical spine injuries.

Artificial airway

The beneficial effect of any or all elements of the triple airway manoeuvre may be lost if discontinued since the mandible or tongue may fall back and (again) obstruct the airway. The insertion of an artificial airway between the tongue and the posterior pharyngeal wall should prevent this.

Oropharyngeal airway

An oropharyngeal airway is the most commonly used artificial airway, as it is relatively simple to insert and should avoid many of the problems associated with the nasopharyngeal airway (see below). It is often used to facilitate oxygenation/ventilation prior to tracheal intubation.
Q. In what clinical situations would an oropharyngeal airway mitigate upper airway obstruction?

A. The oropharyngeal airway is of greatest benefit in the temporary management of upper airway obstruction due to loss of tone in the musculature associated with the airway. This is most commonly due to decreased level of consciousness, potentially due to a myriad of causes including acute hypoxia or hypercarbia, drug overdose/intoxication, induction of/recovery from anaesthesia or cardiorespiratory arrest.

In adults, the oropharyngeal airway should be inserted with the convex side towards the tongue and then rotated through 180 degrees. Care must be taken to avoid pushing the tongue posteriorly and worsening the obstruction.

http://www.aic.cuhk.edu.hk/web8/Hi%20res/oropharyngeal%201_CMYK.jpg

Contraindications to the use of an oropharyngeal airway include (all relative):

- Inability to tolerate oropharyngeal airway (gagging/vomiting)
- Fragile dentition – including presence of prosthetics.

Complications of the oropharyngeal airway:

- Gagging or coughing
- Vomiting and aspiration
- Laryngospasm
- Trauma (teeth, mucosa, tongue etc)
- Worsening airway obstruction
  - Pushing tongue posteriorly
  - Lodgement of tip of airway in vallecula.

**Nasopharyngeal airway**

The nasopharyngeal airway has the same indications as the oropharyngeal airway but is usually more easily tolerated. However, insertion is contraindicated in:
• Adults with blocked or narrow nasal passages
• Patients with fractures of the mid-face or base of skull
• When bleeding from the nasal cavity would be disastrous.

Complications of the nasopharyngeal airway:

• Trauma to nasal turbinates/nasal mucosa
• Bleeding from nasal cavity (especially into pharynx)
• Laryngospasm
• Gagging or coughing (less likely than with oropharyngeal airway)
• Vomiting and aspiration.

Any artificial airway should be looked on as a temporary adjunct – to be replaced with a more secure airway if the patient fails to improve to the point where they no longer need an artificial airway. Similarly such airways should not be used in association with any form of prolonged positive pressure ventilation, although they may be used to facilitate bag-mask ventilation as a preparation for tracheal intubation.

Oxygenation and ventilation

Oxygenation usually requires movement of (inspired) gas down a patent airway to the alveoli. Once a patent airway is achieved, such flow may either be achieved by patient spontaneous effort or by assisted ventilation.

Variable flow face-mask

If the patient is breathing spontaneously, oxygen may be supplied by either a face-mask or a bag-valve-mask device.

Depending on the patient’s tidal volume, peak flow rate and entrainment of ambient air, 100% O₂ with a 8–12 l.min⁻¹ flow through a simple face-mask should result in an inspired O₂ concentration of 40–60%. If a reservoir bag is attached to the mask an inspired oxygen concentration of over 80% may be achieved dependent on the three factors mentioned above. Entrainment of ambient air is minimised by a close fitting mask or a mask which seals the mouth and nose from the ambient air.

Manual ventilation using a mask

If the patient’s spontaneous (negative pressure) breathing is either absent or inadequate it should be augmented or replaced with positive pressure ventilation. This positive pressure can be generated manually, using a bag and mask (as part of an anaesthetic circuit/breathing system) or a bag-valve-mask. A bag-valve-mask (also known as a BVM or e.g Ambu® bag) is a hand-held device used to provide positive pressure ventilation to a patient who is not breathing or who is breathing inadequately. Manual ventilation using a mask and anaesthetic circuit or a BVM is usually only a short-term measure in urgent situations and/or as a preparation for tracheal intubation. The airway should first be cleared using the manoeuvres described earlier. Failure to clear the
airway will produce inadequate ventilation and potential gastric distension and regurgitation.

Ventilation with a mask requires a tight fit between mask and face. This can be best achieved by placement of the mask on the face by holding it with the thumb and first finger (C-grip) and pulling the mandible upward towards the mask with the other three fingers. Excessive pressure on the mask may either lead to flexion of the cervical spine with subsequent airway obstruction or tilt of the mask with lateral leakage, or both. If there are problems sealing the face-mask to the face with one hand, use two hands while a second person squeezes the reservoir bag.

Q. What conditions are likely to make manual ventilation with a bag and mask or a BVM difficult?

A.  
- Anatomical causes such as reduced/no dentition, presence of large jaw or bearded
- Obesity
- Pooling of blood or secretions in the pharynx
- Maxillofacial and nasal trauma or tumours
- Infections and inflammatory disorders
- Facial burns.

Q. How would you maintain oxygenation in an unconscious or anaesthetised patient, who cannot be manually ventilated using a mask despite two person ventilation and insertion of an oropharyngeal airway? What sequence would you follow?

A. Perform one laryngoscopy with optimal positioning and intubate if possible. If intubation is not possible, insert a laryngeal mask airway and attempt ventilation. If still ineffective, waken the patient if this is possible and secure the airway using an awake technique. If unable to ventilate or waken the patient (as is likely in the unconscious critically ill patient), a surgical airway will be required.

Apnoeic oxygenation

Apnoeic oxygenation is oxygenation of blood in the pulmonary capillaries by merely providing a continuous flow of 100% oxygen via a narrow catheter into
the trachea with free egress of gas around the catheter (open system). It will **not**
result in the clearance of carbon dioxide. This may allow 20–30 minutes of
oxygenation without any mass movement of gas (‘apnoea’).

Q. **List two potential indications for apnoeic oxygenation in critical care.**

A.
- As a pre-emptive measure at intubations in situations with presumed difficult
  airway.
- In the ‘cannot intubate—cannot ventilate’ scenario – usually via a needle
cricothyroidotomy.
- During the apnoea test when attempting to establish the diagnosis of brain-stem
death.

Q. **What are the contraindications to apnoeic oxygenation?**

A. Apnoeic oxygenation is contraindicated in patients with established or potentially
raised intracranial pressure due to the detrimental effects of the resulting hypercarbia.

See the PACT module on Traumatic brain injury.

Mort TC, Gabrielli A, Coons TJ, Behringer EC. Airway Management. In: Gabrielli
Philadelphia: Lippincott Williams and Wilkins; 2009. ISBN 978-0-
7817-6869-6. pp. 519–556

**Tracheal intubation**

Main indications for tracheal intubation include:

- Inability to obtain/maintain an unobstructed airway by other means
- Long-term prevention of airway obstruction
- Protecting the airway (lack of protective reflexes)
- Inadequate ventilation or oxygenation
- To facilitate positive pressure ventilation
- To facilitate bronchopulmonary toilet
- Life-threatening haemodynamic instability
- Combativeness that prevents emergency diagnostic studies (need for
  heavy sedation).

When tracheal intubation is difficult, whether anticipated or not, the choice of
simple manoeuvres and/or pieces of equipment can improve the chances of
success. These are described within Task 4.
Orotracheal intubation

Orotracheal intubation is the standard and most reliable technique for those practised in direct laryngoscopy. Normally, analgesedation and neuromuscular blockade are necessary for this procedure. There are no absolute contraindications although the conditions listed under ‘Recognition of anatomical variations/abnormalities’ in Task 1 require careful planning or the use of alternative strategies:

The basic principles should be understood prior to attempting intubation.

The conduct of endotracheal intubation is as follows:

**Prepare and assess the patient**

**Prepare and test the equipment**

- Range of tracheal tubes lubricated and cuffs tested for patency
  - Adult female 7.0–8.0 mm internal diameter
  - Adult male 7.5–9.0 mm internal diameter
- Endotracheal tube introducers
- Syringe for inflating the cuff of the endotracheal tube
- Range of laryngoscopes including specialised blades and handles. Check battery and bulb function
- Functioning suction system
- Appropriate anaesthetic and resuscitation drugs
- Bite protection
- Fixation (tape, tie)
- Facilities for positive pressure ventilation of the lungs with oxygen
- Use of personal protective equipment as appropriate.

There is a trend towards using smaller sized tubes due to some evidence that it may reduce airway trauma. However, narrower tubes increase work of spontaneous breathing and become narrowed or blocked by secretions more easily.

**Optimal patient positioning** (see earlier)

**Preoxygenate** the patient with 100% oxygen for 3–5 minutes if possible.

**Administer drugs**

Intravenous anaesthesia induction agent will depend on the haemodynamic stability of the patient.

- Propofol 0.5–2 mg/kg
- Thiopentone (Thiopental) 1–5 mg/kg
- Midazolam 0.05–0.1 mg/kg,
Although less popular than in the past, ketamine and etomidate are also used by some practitioners in situations with haemodynamic compromise.

Neuromuscular blockade may be achieved with:

- Suxamethonium (succinylcholine) 1–2 mg/kg for rapid sequence
- Atracurium 0.3–0.5 mg/kg
- Vecuronium 0.05–0.1 mg/kg
- Rocuronium 0.6–0.9 mg/kg
- Rocuronium 0.9–1.2 mg/kg has been advocated as a substitute for suxamethonium.

Q. What are (a) the benefits and (b) the disadvantages of using suxamethonium (succinylcholine)?

A. (a)
- Rapidly produces excellent intubating conditions.
- Normally very short acting.

(b)
- Cardiac arrhythmias (bradycardia, tachycardia)
- Hypertension
- Hyperkalaemia
- Histamine liberation
- Myalgia
- Increased intraocular, intragastric & intracranial pressure
- Trismus
- Prolonged neuromuscular blockade (abnormality of succinyl cholinesterase)
- Trigger for malignant hyperthermia

In patients with neuromuscular disorders, e.g. Guillain–Barré, severe hyperkalaemia may develop leading to cardiac arrest and death.

See the following references for more information.

Feneck RO, Cook JH. Failure of diazepam to prevent the suxamethonium-induced rise in intra-ocular pressure. Anaesthesia 1983; 38(2): 120–127. PMID 6829877


Perform laryngoscopy

- Hold the laryngoscope in your left hand near the junction of the handle and blade.
- Insert the blade along the right side of the mouth, displacing the tongue to the left.
• Move blade to midline.
• If using a Macintosh blade, direct the tip of the blade into vallecula between the epiglottis and the base of the tongue. Lift laryngoscope forwards and upwards in the direction of the handle of the laryngoscope to (indirectly) elevate the epiglottis. This should expose the glottis.
• If using a straight blade (e.g. Miller), place the tip of the blade below the epiglottis and lift as described above. This will (directly) elevate the epiglottis and should reveal the glottic opening.
• Avoid angulation of the laryngoscope and using the teeth as a fulcrum.
• Pass the tracheal tube smoothly into the trachea until the cuff is seen to pass 2–3 cm beyond the cords.
• Inflate the cuff.
• Confirm tracheal tube position.
• Assess cuff pressure.


**Choice of laryngoscope blade**

The most widely used blade is the Macintosh. Often size 3 is used as the default for adult patients. Use of the bigger size 4 blade has been shown to be an advantage in visualising the larynx. Other blades, for example, McCoy (a hinged blade tip, controlled by a lever on the handle), may be advantageous in certain situations, particularly where there is a need to maintain minimal cervical spine movement or to reduce the stress response to intubation. The use of straight blades or specialist scopes may be of use in specific situations if the operator has previous experience with these instruments. Adjuncts and specialised equipment required for managing the difficult or abnormal airway are discussed in Task 4.


Nishiyama T, Higashizawa T, Bito H, Konishi A, Sakai T. Which laryngoscope is the most stressful in laryngoscopy; Macintosh, Miller, or McCoy? Masui 1997; 46(11): 1510–1524. PMID 9404140


**Nasotracheal intubation**

Nasotracheal intubation presents several of the problems associated with the nasopharyngeal airway and is used when there are relative contraindications to the oral route. It may be performed by both blind techniques and under direct vision. It may be performed either under general anaesthesia or in the awake patient with appropriate local anaesthesia. A nasotracheal tube is usually better tolerated by ICU patients than an orotracheal tube but is no longer favoured in many health systems due to worries about suboptimal tracheobronchial toilet and reduced drainage from the paranasal sinuses.

May be useful in:

- Patient with short, thick neck
- Jaw clenching
- To maintain minimal neck movement.

Contraindications:

- Nasal fractures
- Mid-face instability
- Base of skull fractures.

**Prepare and assess the patient**

- Use a nasal decongestant such as phenylephrine or xylometazoline to reduce bleeding.
- Examine each nostril for patency and deformity. Choose the most patent nostril and estimate the size of tracheal tube required. This will be smaller than that required for the oral intubation.
- For nasal intubation performed under general anaesthesia (either as a blind procedure or under direct vision – see below), the patient is usually
in the same position as that used for intubation via the oral route.

- Most nasal intubations performed due to concerns regarding difficult airway/intubation are done with the patient awake and sitting up to facilitate placement.

**Blind nasotracheal intubation**

- The patient should be breathing spontaneously.
- Lubricate the tracheal tube well.
- Insert the tracheal tube into the nostril with the concavity forward and the bevel directed laterally.
- While passing the tube downwards listen to audible breath sounds through the tube. By gently rotating the tube, maximum sound intensity should be achieved.
- From there, advance further. On entering the trachea, breath sounds through the tracheal tube and possible coughing may indicate successful positioning.

Blind nasotracheal intubation can be time consuming and is not suitable for rapidly desaturating patients, for example patients with ARDS. Do not force the tube as this could cause bleeding.

**Direct vision nasotracheal intubation**

- Gently advance the tube through the nose as above.
- Perform laryngoscopy.
- When the tube can be visualised in the pharynx advance under direct vision into the trachea.
- If it does not progress, (Magill’s) forceps may be used to direct the tip of the tube.

⚠️ Avoid touching the cuff with the forceps as this may damage the cuff and result in cuff leak and ineffective positive pressure ventilation.

**Fibre optic intubation**

Awake fibre optic intubation is the technique of choice with an informed, prepared patient and a trained operator with appropriate equipment. The technique ensures that spontaneous respiration and upper airway tone can be maintained.

Fibre optic intubation is particularly useful in many clinical scenarios:

- Poor mouth opening
- Abnormal anatomy
- Previous difficult intubation
- Difficult laryngoscopy of a normal larynx
- Determining the nature and extent of pathology
Task 2. Airway interventions

- Correct positioning of single and double lumen tracheal tubes
- Avoidance of dental damage in high-risk patient
- Minimising neck movement
- Direct laryngeal trauma
- Difficult laryngoscopy of a normal larynx.

It may not be useful or appropriate for:

- Open trauma of the upper airway (gross blood soiling)
- Obstruction below the cords
- A narrow glottic opening easily visible with direct laryngoscopy.

**Contraindications (All relative)**

- Respiratory:
  - Laryngeal obstruction
  - Severe hypoxaemia
  - Worsening hypercarbia
  - Severe asthma/bronchospasm
  - Pulmonary hypertension
- Haematological:
  - Thrombocytopenia
  - Coagulopathy

**Advantages of fibre optic intubation**

- Flexibility to manoeuvre through the most difficult airway pathology
- Permits immediate visual confirmation of tube position
- Allows instillation of local anaesthetic and oxygen via the working channel
- Can be used in all age groups
- Facilitates (and facilitated by) the use of other devices
- Success rate is very high
- Most useful back up plan.

**Conduct of fibre optic intubation**

Adequate psychological preparation is essential. Numerous sedation agents have been evaluated, including benzodiazepines, opioids such as alfentanil or remifentanil, and intravenous anaesthetic agents such as (low-dose) propofol infusion. Care must be taken not to overdose the patient and to maintain spontaneous respiration throughout. Supplemental oxygen should be provided, usually through the contralateral nostril. A nasal decongestant such as phenylephrine or xylometazoline to reduce bleeding will be useful particularly when using topical lignocaine.

**Topical anaesthesia**

Topical anaesthetic agents include lignocaine (lidocaine) or cocaine. Cocaine will produce vasoconstriction but has been associated with myocardial
ischaemia. Nebulised lignocaine can be used but may result in high blood lignocaine levels, coughing, and bronchospasm. Anaesthesia of the vocal cords and upper trachea is usually provided by a ‘spray as you go’ technique using 2% lignocaine. Another potential technique is superior laryngeal and recurrent laryngeal nerve blockade.

**Preparation**

- Place tracheal tube on fibrescope and ensure free movement
- Tape tracheal tube lightly to fibrescope
- Check movement of fibrescope tip
- Check orientation of camera
- Reassure patient.

**Passage of fibrescope and tracheal tube**

- Hold fibrescope aloft and straight
- Insert into nasal passage
- Smoothly pass through nasopharynx
- Ask patient to stick out tongue
- Gently suction secretions
- Identify epiglottis
- Slowly advance towards epiglottis
- If view lost, withdraw 1–2 cm
- Smoothly pass through vocal cords (turn may be required)
- Identify tracheal rings
- Advance until carina visible
- Reassure patient – advance tube distally
- Ensure carina remains visible – no endobronchial intubation
- Ask assistant to hold tracheal tube
- Smoothly remove fibrescope
- Reassure patient.

Lavery GG, McCloskey BV. The difficult airway in adult critical care. Crit Care Med 2008; 36(7): 2163–2173. PMID 18552680


Task 2. Airway interventions


Laryngeal mask airway

The laryngeal mask airway (LMA) consists of a small mask at the end of a hollow plastic tube. It is placed ‘blindly’ in the lower pharynx. The laryngeal mask airway sits obliquely over the laryngeal inlet, with the (distal) tip of the mask sitting at the entrance to the upper oesophagus (posteriorly) and the base of the mask at the base of the tongue (anteriorly). The LMA does not protect the airway from aspiration but, if well positioned, positive pressure ventilation (low/moderate pressure) is possible. The LMA has a role in reducing the number of airway catastrophes.

Indications for use of an LMA include:

- Conduit for a flexible bronchoscope
- Within the difficult airway algorithm
- Alternative to (i) oropharyngeal airway and mask and (ii) tracheal intubation in selected surgical procedures – rarely appropriate in critical care (see disadvantages below).

Advantages include:

- Often no more problematic to insert in patients with difficult airways
- Relatively easy to become competent in use with limited training
- Ventilation may be possible using gentle positive pressure
- May be used for intubation once oxygenation has been achieved
- Will facilitate passage of tube or fiberscope
- May help avoid catastrophic outcome in difficult airway scenario.

Contraindications:

- Lack of training and experience
- Patients with an active gag reflex
- Foreign body airway obstruction
- Severe oropharyngeal trauma.

Disadvantages include:

- The airway is not protected from aspiration
- It may move during use and cause airway obstruction
- It does not allow high airway pressures (ventilation with poor chest/lung compliance) to be generated in the airways
- May be dangerous in supraglottic, glottic and infraglottic obstruction
- Does not always provide an adequate airway.
Task 2. Airway interventions


Ferson DZ, Rosenblatt WH, Johansen MJ, Osborn I, Ovassapian A. Use of the intubating LMA-Fastrach in 254 patients with difficult-to-manage airways. Anesthesiology 2001; 95(5): 1175–1181. PMID 11684987

**Developments of Laryngeal Mask Airway**

In 2002 a variation of the classical LMA was introduced. It incorporates an oesophageal (posterior) cuff and lumen for venting of stomach contents. It maintains a seal with higher airway pressures than the standard LMA. Accurate fixation is required in order to maintain the distal end at the upper oesophageal sphincter.


A single-use LMA-type supraglottic airway, e.g. i-gel, has a gel-filled non-inflatable seal. It moulds to the pharyngeal, laryngeal and perilaryngeal structures and claims to reduce pressure on airway mucosal surfaces. When correctly inserted, the tip of the i-gel is located at the entrance to oesophagus and the ‘gastric channel’ allows for suctioning of the oesophagus and stomach, passing of a nasogastric tube and venting of trapped gas. It is claimed that optimum positioning is more often achieved with the i-gel.

**Intubating laryngeal mask airway**

It is possible to pass a size 6.0 mm tracheal tube though a standard LMA into the trachea. However this is not always successful and the LMA must be left in situ. A modification of the LMA has been developed specifically to aid intubation. The Intubating LMA (iLMA) has a steel tube which is shorter and of wider bore than the silicone tube of the standard LMA. There is a bar at the distal opening that allows the epiglottis to be lifted anteriorly. Through this will pass a special size 8 ETT with a soft tip and a narrow cuff. The process of using the iLMA to place an ETT is shown the figures below.
Oesophageal-tracheal double lumen device

As the name suggests this is a double lumen tube with luminae that end at approximately the same level. The oesophageal lumen has eight perforations that are intended to be located at the level of the lower pharynx. This lumen is blind at the distal end. The other lumen (tracheal) is open at the distal end and unperforated throughout. There are two balloons, one smaller distal and a larger proximal balloon. The larger balloon fixes the combitube in the hypopharynx. The distal balloon forms a seal either in the oesophagus or the trachea. Marketed as Combitube™, the device can be inserted blindly or with the aid of a laryngoscope.

In about 95% of the cases the combitube ends up inserted into the oesophagus. Ventilation then takes place via the perforations in the wall of the oesophageal tube. It is indicated only in the ‘cannot intubate–cannot ventilate’ situation. Its major disadvantage is that no tracheal suctioning is possible if the distal lumen is placed in the oesophagus (the most likely position).

Cricothyroidotomy

Cricothyroidotomy may be performed as a percutaneous or open surgical procedure.

- The percutaneous insertion of a cannula through the cricothyroid membrane into the airway will allow apnoeic (low pressure) or jet (high pressure) ventilation to be performed.
- Surgically opening the membrane will allow the passage of a small tracheostomy tube through which ventilation can take place.

The indication for both these techniques is in the ‘cannot intubate–cannot ventilate’ situations which are rare. While puncturing the trachea is a significantly invasive procedure, it should be performed before critical hypoxia has occurred.

Cricothyroidotomy is usually reserved for emergency airway access, however, the technique is similar to insertion of a minitracheostomy.

Practise the technique in the simulation situation or as part of another procedure e.g. transtracheal injection or insertion of a ‘minitracheostomy’ tube. Avoid the first time being the ‘failure to intubate–failure to ventilate’ scenario.
**Equipment**

- Cannula with or without catheter
- Non-kinking dilator
- Guide wire
- Syringe
- Lignocaine (lidocaine)
- Scalpel
- Minitracheostomy tube.

**Seldinger technique**

- 100% oxygen by face-mask or bag-mask ventilation by assistant.
- Extend the neck if possible.
- Prepare the skin with antiseptic.
- Palpate the landmarks of the thyroid and cricoid cartilages in the midline. The cricothyroid membrane is a trapezoid shaped membrane lying between these two cartilages.
- Anaesthetise the skin with subdermal lidocaine and adrenaline.
- Insert a needle and cannula through the skin and cricothyroid membrane perpendicularly while aspirating until air enters the syringe. Make sure that the opening of the sharp end is directed caudal. Do not advance further and do not enter the oesophagus. Remove the needle while slightly advancing the cannula.
- Insert guide wire. Often this will provoke coughing. The wire should advance without resistance. Do not force it.
- Perform a small incision in the skin at the entry point of the guide wire.
- A dilator is inserted over the guide wire and then removed.
- A mounted minitracheostomy tube may be threaded into the trachea. Remove the inner dilator.
- Pass a suction catheter into the trachea to confirm that there is no obstruction.

**Ventilation through the cricothyroidotomy**

There are several techniques for ventilating through the cricothyroidotomy some of which require preparation. It is imperative that the equipment should be preassembled on the difficult airway trolley or bag. There is unlikely to be the time during an emergency, ‘failure to intubate–failure to ventilate’ scenario. There are new commercial preassembled devices available.

**Complications of cricothyroidotomy**

Although the technique may be complicated by bleeding, airway compromise or tube misplacement, complications are usually due to ventilation and include:

- Barotrauma
- Aspiration
- Inadequate ventilation.
Tracheostomy

Tracheostomy, performed either as an open (surgical) or percutaneous technique, is a long-term alternative to orotracheal or nasotracheal intubation. The latter technique is now more common and uses a Seldinger technique to place a guide wire in the trachea. The track to the trachea is then dilated using single or multiple dilators (or more recently by inflating a balloon) passed over the wire (see below). The procedure is performed under bronchoscopic control. Percutaneous tracheostomy is usually performed in the ICU by the intensivist whilst almost all operative tracheostomies are performed in the operating theatre/room.

The advantages of a tracheostomy are:

- Patient comfort and reduced need for sedation
- Reduction in supra-and subglottic trauma/scarring
- Patient has potential to speak.

The indications are:

- Failure to wean from mechanical ventilation
- Prevention of damage to vocal cords and subglottic region
- Absence of protective airway reflexes
- Inability to maintain a patent airway
- Need for tracheobronchial toilet with suctioning
- As part of a surgical procedure e.g. laryngectomy
- Prolonged or anticipated prolonged invasive ventilation.

Contraindications (both techniques):

- Arterial injury in neck
- Coagulopathy (depending on the type of procedure).

Contraindications (percutaneous technique):

- Abnormal anatomy
- Suspected cervical spine instability.

Complications:

- Unsuccessful placement (failure)
- Incorrect placement (apparent success)
- Haemorrhage
- Local infection; might particularly compromise patients who have required surgical fixation following cervical spine injury.

Earlier studies comparing percutaneous and surgical tracheostomy suggested more minor complications with percutaneous tracheostomies. However, the message from a significant number of studies and meta-analyses is that the percutaneous technique has similar operative complications, fewer infective complications, shorter scars with better cosmetic results and possibly less
bleeding. Since it is performed at the bedside, it is superior in terms of cost and practicality.


**Timing of tracheostomy: early versus late**

At what point in the care of a patient who is ‘failing to wean’ should a tracheostomy be performed? There is no concensus on this point – as early as seven days or as late as 21 days are not uncommon. However, in a patient who definitely requires the procedure (e.g. for airway protection) it seems sensible to perform it early to provide the advantages of comfort and reduced sedation. The references below discuss the factors which influence the timing of tracheostomy.


**Percutaneous tracheostomy**

- Position the patient with a roll beneath the shoulders to extend the neck.
- Prepare the neck as above.
- Palpate the cricoid and the upper tracheal rings and infiltrate with lignocaine (lidocaine) and adrenaline if necessary.
- Advance fibre optic scope through the tracheal tube.
Task 2. Airway interventions

- Withdraw the tracheal tube until the cuff lies at or below the cords and can be kept inflated to maintain a seal for ventilation.
- When using the Ciaglia or Griggs technique make a 1.5–2 cm transverse incision over the second tracheal ring and blunt dissect to the trachea.
- Under fibre optic vision puncture the trachea in the midline until air is aspirated.
- Insert a J tipped Seldinger wire again checking that this is in the midline.
- The dilating techniques use sequential dilators (Ciaglia technique), a forceps (Griggs technique), a single rhino dilator or a screw (Percutwist). Once dilated remove the dilators and then insert a tracheostomy tube.
- Inflate the cuff. Place a suction catheter through the tube to remove blood and secretions and confirm tube position using the endoscope.
- Obtain chest X-ray to confirm position and rule out complications.
- The Fantoni technique for percutaneous tracheostomy involves retrograde intubation of the trachea using a specially-designed tracheal tube. This is a more complex technique and is not as widely practised. Its proponents claim that it can be used safely in patients with bleeding tendencies because of the tension on the tissues.

Q. What are the complications of percutaneous tracheostomy and which are the most common?

A. A large number of complications have been reported with percutaneous tracheostomy including death, bleeding, pneumothorax, subcutaneous emphysema, tube displacement, stomal infection, pneumonia, tracheal stenosis, tracheoesophageal fistula.


Observe five percutaneous tracheostomies and five operative tracheostomies to compare and contrast the different techniques.

In the Intensive Care Unit or by visiting the Anaesthetic Recovery Ward, observe the various methods of oxygenation/airway management being used on patients e.g. simple oxygen mask, oropharyngeal airway, endotracheal or tracheostomy tube. Consider why different techniques are used in different patients.

**Tracheostomy tubes**

Modern tracheostomy tubes are made of plastic and may be classified by various aspects of their construction. Tubes may be cuffed or uncuffed, single or double lumen (with an inner removable cannula), fenestrated or non-fenestrated and may have an adjustable (rather than fixed) flange. In addition, they may have foamed filled cuffs, or have specific shapes or dimensions for particular clinical situations. The inner removable cannula is an important safety feature in the event of tracheal obstruction, see Task 5.

Hess DR. Tracheostomy tubes and related appliances. Respir Care 2005; 50(4): 497–510. PMID 15807912
3. RECOGNITION OF EFFECTIVE VENTILATION

The critical care physician should be aware that one of the major causes of death or severe brain damage in anaesthesia relates to the failure of ventilation due to the misplacement of the endotracheal tube. Unrecognised oesophageal intubation is as likely to occur in the situation of apparently uncomplicated intubation as in the difficult intubation scenario. The outcome may be more devastating in the uncomplicated intubation because of the potential delay in the appearance of clinical signs and the reluctance to believe that the endotracheal tube has been misplaced.

**Anecdote**  A fit 20-year-old man was anaesthetised for an emergency appendectomy. He was pre-oxygenated for five minutes. A rapid sequence induction and endotracheal intubation was performed and air entry was heard bilaterally. Ten minutes into the procedure the patient’s oxygen saturation fell. The patient suffered a cardiac arrest. A more experienced assistant arrived and connected an end-tidal carbon dioxide monitor. End-tidal carbon dioxide was absent. The tracheal tube was removed from the oesophagus and repositioned in the trachea. The patient was resuscitated but suffered severe hypoxic brain injury resulting in a persistent vegetative state. Pre-oxygenation allowed the oesophageal intubation to go unrecognised for ten minutes by which stage the intubator was reluctant to believe that the tube was malpositioned.

**Correct tracheal tube positioning**

The optimal position for the tracheal tube ensures that the upper end of the cuff lies 1–3 cm below the vocal cords and the tip of the tube lies 2–3 cm above the carina.

**Anatomy of the airways**

In the adult, the distance from the incisors to the vocal cords is 12–15 cm. The length of the trachea from the underside of the vocal cords to the carina is approximately 11 cm. The distances may differ depending on gender and anatomy but in general the distance from the distal end of the tracheal tube to the incisors will be 21 cm in women and 23 cm in men.

**Confirmation of tracheal tube placement**

**!** Flexion and extension of the cervical spine can result in movement of the tracheal tube up to 3.5 cm and consequently can result in accidental misplacement of the tube. This is a particular risk in children.

**!** Only two methods are safe to prove correct endotracheal tube position: direct visualisation of the tracheal tube between the vocal cords and positive measurement of end-tidal carbon dioxide.
Visualising the tube passing into the trachea

This should be the gold standard in assessing the correct positioning of the tracheal tube. It is of no benefit if a good view of the larynx cannot be achieved. However, operator error can occur and the intubator is often reluctant to believe that oesophageal intubation has occurred. This may lead to a devastating delay in making the diagnosis (see above anecdote). In addition, accidental dislocation of tube may occur when removing the laryngoscope.

Chest wall movement on manual ventilation

It is often possible to see chest movements on manual ventilation; however chest wall movements may be difficult to see in the obese or in the presence of airway obstruction. Following (inadvertent) intubation of the oesophagus, manual ventilation will cause inflation of the stomach which may give the appearance of chest wall movement.

Presence of water vapour condensing on the tracheal tube (‘misting’)

Cyclic appearance of ‘misting’ on the wall of tracheal tube during exhalation is a pointer to successful tracheal intubation. However, water vapour is also produced from the oesophagus which may be misleading. The absence of water vapour is usually indicative of oesophageal intubation.

Auscultation of breath sounds

Both axillae should be carefully auscultated for clear vesicular breath sounds.

Beware. There are usually transmitted sounds audible over the anterior chest wall with oesophageal intubation especially in children. In blunt thoracic trauma or in certain pulmonary pathologies (especially unilateral), diminished breath sounds may not indicate a wrong tube position.

Compliance of the reservoir bag

The characteristic feeling of the reservoir bag during manual ventilation is not always reliable as gas coming back from the stomach can have a similar feel.

End-tidal carbon dioxide

Besides direct visualisation of correct tube placement, detection of end-tidal carbon dioxide is the second reliable sign of correct tracheal tube placement.

Q. What are the situations where end-tidal carbon dioxide monitoring may be misleading?
A.

- After oesophageal intubation, carbon dioxide may be detected (from the stomach) if significant gastric inflation has occurred during manual ventilation with a mask. This should cease after 2–3 ventilatory cycles.
- After oesophageal intubation, carbon dioxide may be detected on capnography where carbonated drinks have been taken shortly prior to the intubating event. The end-tidal levels of carbon dioxide should decrease relatively quickly.

**End-tidal carbon dioxide should be monitored for at least six respiratory cycles before being taken as a confirmatory test.**

End-tidal carbon dioxide monitoring may not always be available especially in the emergency situation. Disposable devices which work on colourimetry can be useful in the emergency situation.

**Negative pressure devices**

Negative pressure devices rely on the principle that if negative pressure is applied to a tube in the oesophagus that occlusion will occur as the oesophagus collapses around the tube. A 50 ml syringe with a catheter tip attached to the tube via a catheter mount can be used with success.

**Attempt to construct a negative pressure device and get the feel for the normal in the elective situation. Check your emergency airway equipment for the range of devices required. There will not be the time in the emergency situation. Such detection devices should not be necessary where ETCO₂ monitoring is available.**

**Fibre optic confirmation**

Although visualising the carina via a fibre optic bronchoscope will confirm correct placement, this technique is often only of practical benefit where the scope has been used to perform the intubation.

**Radiology**

Whilst a chest X-ray will be of little use in the acute situation, the correct position of the tracheal tube should be confirmed in all patients in intensive care. However, an apparently normal chest X-ray appearance does not guarantee correct tracheal placement of a tube (orotracheal or tracheostomy).
Q. Where is the optimal position of the tracheal tube on the chest X-ray? Give three possible malpositions. See the images below.

A. The tip of the tracheal tube should lie approximately 2–3 cm above the carina. The tube may be misplaced into the:

- Right main bronchus
- Left main bronchus
- At the level of the vocal cords with cuff outside the cords
- Outside the airway.
4. THE DIFFICULT AIRWAY: ALGORITHMS & ADJUNCTS TO MANAGEMENT

The difficult airway has been defined as a clinical situation in which a conventionally trained anaesthesiologist experiences difficulty with mask ventilation, tracheal intubation, or both. It is a situation in which the conventionally trained critical care physician seeks expert anaesthesiology assistance.

Critical incidents related to airway management may have devastating consequences ranging from hypoxic brain injury to death. The likelihood of disaster is greatly diminished if the difficult intubation is anticipated. Thorough patient assessment will reduce the incidence of unrecognised difficult intubation.

Unfortunately all difficult intubations are not predictable. It is of paramount importance that those involved in any form of airway management possess a range of techniques to deal with the unanticipated difficult airway.

All airway manoeuvres in the critically ill patient should be anticipated as difficult. Even where the grade of laryngeal visualisation is known to be easy, the patient may be hypoxaemic and cardiovascularly unstable. Re-intubations may be complicated by laryngeal oedema, upper airway secretions and gastric contents.

**Difficult airway guidelines**

Two algorithms are shown:

**Difficult airway algorithm 1**

**Difficult airway algorithm 2**
http://pact.esicm.org/courses/AIRMAN/scorm/airway_management/pdf/AirMan_algoritm2.pdf

Further information is given in the references below.

Lavery GG, McCloskey BV. The difficult airway in adult critical care. Crit Care Med 2008; 36(7): 2163–2173. PMID 18552680


Benumof JL. Management of the difficult adult airway with special emphasis on awake tracheal intubation. Anesthesiology 1991; 75(6): 1087–1110. PMID 1824555

Link to: http://www.asahq.org/publicationsAndServices/practiceparam.htm

Many national bodies/societies have published difficult airway guidelines. Go online and try to find your own national guidance and compare it with the guidelines within this module.

Difficult intubation

Difficult intubation may be considered under three headings:

- Anticipated difficult intubation
- Unanticipated difficult intubation
- Failure to intubate and failure to ventilate.

Anticipated difficult intubation

A 35-year-old man required intubation and general anaesthetic for internal fixation of facial fractures following an assault whilst intoxicated. An awake fibre optic intubation was attempted but the patient was uncooperative and combative. When sedation was administered, the patient’s breathing became laboured and obstructed. Further sedation was administered and the patient became apnoeic. Intubation was attempted; however the larynx was not visible. A cricothyroidotomy was performed to maintain oxygenation and a tracheostomy was required.

Whenever difficulty with intubation is anticipated there are several decisions required to determine the best course of action.
Step 1: Should the patient be awake or anaesthetised

Anticipated difficult intubations, where the difficulty is viewed as significant, should be performed using an awake technique wherever possible. For ‘lesser’ degrees of difficulty, anaesthesia and the use of adjuncts described later in this Task may be appropriate. This is a significant ‘judgment call’ involved, requiring considerable care and experience.

**Note**

Awake techniques may require more time, require additional operator skills, especially in providing airway anaesthesia and may be more unpleasant for the patient.

The benefits of awake techniques normally outweigh the risks since:

- The risks of hypoxia are greatly diminished as the patient can be kept spontaneously breathing throughout the procedure.
- The awake patient can maintain the tone of the upper airways allowing separation of the structures from one another. This allows improved visualisation of the larynx.

Step 2: Which awake technique is most appropriate: Fibre optic or retrograde?

**Flexible fibre optic endoscopy**

- Most popular and accessible awake technique for intubation.
- Requires specialist equipment, training and practice and is not suitable for all patients.
- When used appropriately, it is a rapid safe technique with a high level of success.

**Q. What are the contraindications to awake fibre optic intubation?**

A.

- Unwilling patient despite adequate preparation.
- Inexperienced operator – this should not be underestimated as the potential for airway disaster is greatly increased.
- Bleeding may obscure the view.
- Subglottic obstruction – where the tube may not pass into the trachea.

**Retrograde techniques**

- Used for several decades and recently have become more popular because of the development of new equipment and the combination of retrograde and fibre optic techniques.
- Retrograde techniques have been shown to be of particular benefit in maxillofacial trauma.
- As with the other awake techniques, considerable skill and practice are necessary to ensure a high degree of success.
Step 3: If general anaesthesia is used, which technique is most appropriate

There will be some circumstances where an awake technique may not be feasible (when dealing with the uncooperative patient) or necessary (if the degree of difficulty is not thought to be severe). If general anaesthesia is to be induced then the utmost care should be taken with preparation of the patient, assistance and equipment.

- Ensuring an empty stomach – use a large nasogastric tube if required
- Optimal positioning
- Prolonged pre-oxygenation with full monitoring applied
- Prepare all the necessary adjuncts to difficult intubation (see below)
  - Gum elastic bougie
  - Range of laryngoscope blades and handles
  - Introducers
  - Video laryngoscopy equipment
  - Illuminating stylets
  - Laryngeal mask airways
  - Transtracheal kit.

The patient should be kept spontaneously breathing at all times until the operator is sure that both intubation and ventilation are possible. If laryngoscopy is performed and intubation is found to be difficult, repeated attempts at intubation should be avoided as the likelihood of significant adverse effects increases with prolonged attempts and increased use of force.

⚠️ Do not administer a muscle relaxant (neuromuscular blocking drug) if there is concern about the ability to visualise and intubate the larynx.

Unanticipated difficult intubation

Even with proper patient assessment and selection, not all difficult intubations are predictable. The focus must be to maintain adequate oxygenation at all times. If at any stage, ventilation by mask becomes difficult, the procedure should be abandoned, the patient awakened (if feasible) and the airway should be secured under local anaesthesia if possible. Skilled assistance should be immediately sought.

Lavery GG, McCloskey BV. The difficult airway in adult critical care. Crit Care Med 2008; 36(7): 2163–2173. PMID 18552680

Task 4. The difficult airway: algorithms & adjuncts to management


Simple techniques for the unanticipated difficult intubation

Use the simple techniques below frequently. Optimising every intubation will significantly reduce your incidence of difficulty and improve your technique with these devices.

**BURP and Bimanual Laryngoscopy**

Backward Upward and Right Pressure (BURP) over the larynx often improves the view at laryngoscopy. However, when performed by an assistant who cannot see its effect on the laryngeal position, it has been shown to worsen view in over 30% of cases. The optimal degree and direction of pressure on the larynx can be found by the intubator using trial and error and, when the optimum view has been achieved, maintained by an assistant. This is known as Bimanual Laryngoscopy or External Laryngeal Manipulation (ELM).


Yentis SM. The effects of single-handed and bimanual cricoid pressure on the view at laryngoscopy. Anaesthesia 1997; 52(4): 332–335. PMID 9135184

Snider DD, Clarke D, Finucane BT. The ‘BURP’ maneuver worsens the glottic view when applied in combination with cricoid pressure. Can J Anaesth 2005; 52(1): 100–104. PMID 15625265

Pressure is exerted on the thyroid cartilage not to the cricoid!

**Use of a Gum Elastic Bougie**

The gum elastic bougie is a long, blunt-ended, semirigid introducer which is advanced (sometimes blindly) through a poorly visualised (or unseen) larynx and into the trachea. Its insertion into the trachea may be confirmed by feeling (NOT hearing) the ‘clicks’ as the bougie runs over the tracheal rings. The patient may cough (if muscle relaxation is not complete). A tracheal tube can then be railroaded over the bougie. The tip of the tube bevel may catch on the right vocal cord. If so the tracheal tube should be rotated anticlockwise through 90° and advanced.

Many view the gum elastic bougie as the best single adjunct in airway management. However it may be of limited value when it is not possible to elevate or visualise the epiglottis. There have also been reports suggesting an increased frequency of failure with the more recently introduced single-use
bougie. It must be used with care as vigorous advancement may perforate the oesophagus or even the major airways.

Hames KC, Pandit JJ, Marfin AG, Popat MT, Yentis SM. Use of the bougie in simulated difficult intubation. 1. Comparison of the single-use bougie with the fibrescope. Anaesthesia 2003; 58(9): 846–851. PMID 12911355

Marfin AG, Pandit JJ, Hames KC, Popat MT, Yentis SM. Use of the bougie in simulated difficult intubation. 2. Comparison of single-use bougie with multiple-use bougie. Anaesthesia 2003; 58(9): 852–855. PMID 12911356


Use of a Stylet (Introducer) or Lighted Stylet/Light Wand

The stylet is a smooth, malleable metal or plastic rod that is placed inside a tracheal tube (ETT) to adjust the curvature, typically into a J or ‘hockey-stick’ shape to allow the tip of the ETT to be directed through a poorly visualised or unseen glottis. The stylet should not project beyond the end of the ETT to avoid potential airway injury.

The lighted stylet (light wand) is a malleable fibre optic light source on which an ETT can be mounted and subsequently railroaded into the trachea when the light source has passed beyond the glottis. By trans-illumination of the soft tissues of the anterior neck it distinguishes the tracheal lumen from the (more posterior) oesophagus. Low ambient lighting is required for its use. The use of the lighted stylet may facilitate blind intubation with a reduced stress response and reduced neck movement. However, intubation using the lighted stylet may take longer than some other techniques/procedures and it is unsuitable for the obese patient with a thick neck.


Benumof JL. Comparison of the gum elastic bougie and the stylet. Anaesthesia 1997; 52(4): 385–386. PMID 9135199


Use of a modified laryngoscope blade

- Straight blade (1 of 2 standard blades used in US)
- McCoy laryngoscope
• Polio blade
• Video laryngoscope.

You will find examples of laryngoscopes in the following.

http://www.frca.co.uk [Resources/Physics and Equipment/Laryngoscopes]

http://www.penlon.com/products/laryngoscopes/mc_coy.html


Cook TM, Tuckey JP. A comparison between the Macintosh and the McCoy laryngoscope blades. Anaesthesia 1996; 51(10): 977–980. PMID 8984878

Chisholm DG, Calder I. Experience with the McCoy laryngoscope in difficult laryngoscopy. Anaesthesia 1997; 52(9): 906–908. PMID 9349078

Consider using a different blade in some intubations with the appropriate involvement of an experienced user of the blade. If you have access to a simulation suite perform ten elective laryngoscopies using two different laryngoscope blades. Compare and contrast the individual blades for ease of use, view at laryngoscopy and potential unwelcome effects.

Advanced techniques for the unanticipated difficult intubation

If intubation cannot be accomplished with simple techniques, the patient should be awakened if possible. Advanced techniques may be used as aids to intubation or as rescue techniques to maintain oxygenation whilst the patient is being awakened.

Success with any of the following techniques relies more on the skill of the operator than on the tools themselves. It is imperative that experience is gained in the use of a wide range of advanced airway techniques.

Use of the laryngeal mask airway or intubating LMA

The LMA can be used to achieve control of the airway whilst a definitive procedure is performed or the patient is awakened. It may be possible to intubate blindly through an LMA. This is technically difficult and is made easier by the use of an intubating laryngeal mask airway (see Task 2).
Q. What are the contraindications for insertion of the laryngeal mask airway in the emergency setting?

A. Upper and lower airway haemorrhage, full stomach, vomitus in pharynx (possibility of gastric aspiration), direct laryngeal trauma, severe head trauma (relative contraindication).

**Video laryngoscopy**

These devices use digital video technology and modified laryngoscope blades to improve visualisation of the glottis. These have a monitor/display which allows visualisation of the tracheal tube as it moves through the laryngeal opening and increases the operators breadth of view from 15 degrees to 60 degrees.

Current examples include the GlideScope®, the McGrath® series 3 laryngoscope, and the Storz C-MAC® which have curved (Macintosh-like) blades. The Pentax AWS® and AirTraq® have a straight (Miller-like) blade which, like the original, passes under the epiglottis and elevates it by direct upward pressure. They also have a channel to guide the tracheal tube.

All these devices promise usefulness in patients with limited mouth opening and reduced neck extension. Video laryngoscopic devices might be used in a planned way in managing patients with difficult airways or as (unplanned) rescue devices following failed attempts at intubation. In one study of 200 consecutive intubations, see reference below, the GlideScope provided a laryngoscopic view equal to or better than that of direct laryngoscopy. Surprisingly, subsequent tracheal intubation using the GlideScope was slower requiring on average an additional 16 s compared to that with standard direct laryngoscopy. Similar findings have been described by others.

While their popularity is increasing, routine use is still an uncommon occurrence in many health systems. As with all such devices, familiarity with the equipment facilitates successful use in the emergency situation. A recent meta-analysis concluded ‘currently available data do not provide strong evidence that these devices should supersede standard direct laryngoscopy for routine or difficult intubation’. This view may change in the future as our experience increases and these devices undergo technological refinement.


Ferson DZ, Rosenblatt WH, Johansen MJ, Osborn I, Ovassapian A. Use of the intubating LMA-Fastrach in 254 patients with difficult-to-manage airways. Anesthesiology 2001; 95(5): 1175–1181. PMID 11684987
Savoldelli GL, Schiffer E, Abegg C, Baeriswyl V, Clergue F, Waebel JL. Comparison of the Glidescope, the McGrath, the Airtraq and the Macintosh laryngoscopes in simulated difficult airways. Anaesthesia 2008; 63(12): 1358–1364. PMID 19032306


Flexible fibre optic intubation

The fibre optic scope is undoubtedly of great benefit to those skilled in its use. It may be of value in an unanticipated difficult airway if it is ‘ready to go’ and the expertise is immediately available. Beware the scenario in which the patient is already in airway difficulty, time is required to set up the scope and/or the operator has limited skill.

Failure to intubate and failure to ventilate

⚠️ This is an absolute medical emergency, a life-threatening situation, the response to which requires regular practice.
Immediate management

- Give 100% oxygen
- Call for help
- Oral and or nasal airway
- Attempt two person mask ventilation
- Attempt one further intubation under optimal conditions—BURP, gum elastic bougie and best laryngoscope
- IF FAIL, attempt to insert a laryngeal mask airway or oesophageal-tracheal double lumen device
- IF FAIL, proceed rapidly to invasive airway such as needle cricothyroidotomy, miritracheostomy by Seldinger technique or open cricothyroidotomy
- Return to awake state with spontaneous ventilation, or consider conversion to tracheostomy, or (if prospects for successful laryngoscopy can be improved), oral or nasal intubation.

There are few indications to perform a formal tracheostomy for failure to ventilate situations. The procedure takes time and skill and is associated with a significant complication rate.

Q. What are the complications of performing needle cricothyroidotomy and transtracheal ventilation?

A. Bleeding into the lower airways, oesophageal perforation, pneumothorax, pneumomediastinum, pneumopericardium are all possible. However the main complications relate to ventilation rather than insertion. It is essential that the needle or miritracheostomy is in the midline and air is aspirated before ventilation is commenced. The cannula can kink or be displaced into the subcutaneous tissues resulting in subcutaneous emphysema. If the glottis is not open then expiratory obstruction will occur with severe barotrauma.


Liaise with an anaesthesiologist performing transtracheal injections for awake tracheal intubations. If you can practice with the technique, it will allow you to attain familiarity and appreciate the ‘feel’ of the loss of resistance on insertion of the needle.
Extubation of the difficult airway


Extubation of the difficult airway can result in significant morbidity to the patient. Each airway operator is recommended to have a pre-formulated strategy for extubating the difficult airway.

If swelling of laryngeal/pharyngeal structures has been a factor in the development of the difficult airway, the airway may occlude after extubation. With the tracheal tube in situ and a breathing circuit attached, deflate the cuff and apply manual positive pressure to the circuit (a ‘leak test’). Does this produce the expected leakage into the oral cavity around the tracheal tube? If not, it is probable that extubation will lead to further airway/breathing difficulties. Before deflation of the cuff, ensure that secretions located above the cuff have been suctioned in order to prevent pulmonary aspiration.

Airway exchange catheter

Several hollow flexible airway exchange catheters are available which allow ventilation either by jet ventilation or insufflation of oxygen. The catheter is placed through the tracheal tube ensuring that the end of the catheter is above the carina. The tracheal tube can then be removed following a successful ‘leak test’. The stylet may remain in situ until the patient is free from the need for possible reintubation.

Q. What are the side effects of jet ventilation through the airway exchange catheter?

A. The main and most dangerous complication is barotrauma resulting in tension pneumothoraces. This is particularly likely if the tip of the catheter is below the carina. The catheter may move whilst in place and may move into the oesophagus.
5. PITFALLS IN AIRWAY MANAGEMENT

While critical care entails multi-organ support, its every day ‘smooth’ provision is very dependent on the patency of the airway and the functionality of artificial airways. When working well, care is relatively straightforward but a difficulty in this area will destabilise management and threaten the patient very quickly. Familiarity with airway pitfalls and their rectification is a key critical care skill.

Ineffective breathing despite artificial airway

This problem is diagnosed by the presence of ongoing dyspnoea, hypoxia and/or unresolving or worsening hypercarbia. Potential aetiologies include:
1. Airway is still partially/completely obstructed
2. Depressed respiratory drive
3. Inefficient respiratory effort
4. Abnormal pulmonary physiology.

The first step here is to check the airway and follow the steps as described in Task 3. If the airway is unobstructed and the patient’s condition does not improve, then conditions 2, 3 or 4 (listed above) apply. All require the initiation of manual ventilation prior to a more permanent solution. This may involve the use of mechanical ventilation and the use of PEEP.

Q. What conditions may be associated with inefficient (spontaneous) respiratory effort?

A.
- Splinting – fractured ribs, pain, abdominal distension.
- Muscle fatigue/weakness: tachypnoea, neurological deficit, myopathy, myasthenia gravis, polyneuritis.
- Parenchymal lung disease: COPD, oedema, fibrosis.
- Pleural disease: (tension) pneumothorax, large haemothorax or effusion.
- Respiratory depression: intoxication/narcotics, brain injury.

For discussion of the control of normal respiration – see PACT module on Respiratory failure
For information on mechanical ventilation and PEEP see PACT module on Mechanical ventilation.

Ineffective manual mask ventilation despite artificial e.g. oropharyngeal airway

- Airway is still partially/completely obstructed
- Poor seal with mask/poor manual ventilation technique
- Abnormal pulmonary physiology.

Again the correct strategy is to go back to the airway. Is it clear? If this is in doubt, a definitive airway (e.g. orotracheal tube) will be required after attempting to improve oxygenation/CO₂ removal with more effective mask ventilation.
To achieve the latter:

- Check/readjust airway and patient head position
- Use both hands to provide seal between face and mask (second person to provide positive pressure on bag)
- Get someone with more airway experience – if readily available
- Increase FiO₂ (to 1.0) and fresh gas flow to 15–20 l/min.

When oxygenation and CO₂ removal is judged satisfactory or best possible, tracheal intubation should then be attempted. If oral/nasal intubation is not possible then a surgical airway should be obtained.

**One-sided intubation and ventilation**

The distance from the vocal cords to the bifurcation of the trachea (carina) in the average adult is 11–12 cm. The tip of an 8.0 (adult) tracheal tube is typically 6.5 cm below the upper surface of the balloon. Thus, even if the upper surface of the balloon is almost touching the lower surface of the vocal cords, there is just over 5 cm between the tip of the tracheal tube and the carina. It is therefore quite easy to inadvertently place a tracheal tube so that the tip lies beyond the carina. In adults with normal bronchial anatomy, the tube tip will usually (but not always) pass into the right main bronchus.

One-sided intubation and ventilation may be diagnosed by auscultation of the chest immediately after intubation. Absent or diminished breath sounds/air entry in one hemithorax (particularly on the left side) should suggest bronchial intubation. This may be supported by a number of other signs.

**Q. In a patient with unilateral breath sounds after placement of a tracheal tube, what other findings would support the diagnosis of unilateral (usually right sided) bronchial intubation?**

**A.**

- Reduced expansion of (left) hemithorax.
- (Slightly) reduced oxygen saturation on oxymetry (SpO₂).
- Requirement for high FiO₂ to maintain normal SpO₂.
- Excessive tube length passed as judged by tube markings at teeth/lips.
- Reduced compliance on manual ventilation (‘stiff lungs’).
- High inspiratory pressure and/or poor inspiratory tidal volume if using mechanical ventilation.

If bronchial intubation is suspected, deflate the tracheal tube cuff and slowly withdraw the tube 1–2 cm. Re-inflate the cuff and manually ventilate the patient while auscultating both sides of the chest. Is air entry present and equal? Be
suspicious if the tube has to be withdrawn more than 3–4 cm. Observe the tube length marking at the teeth. If it is much less than the expected correct length, you may be dealing with another diagnosis (see below).

Visit the operating theatre/room and request to auscultate the lungs of patients on manual or mechanical positive pressure ventilation. Become familiar with what normal air entry in this situation sounds like. Would you be able to detect unilateral intubation? How quickly would you be able to make that judgment?

Q. Excluding bronchial intubation, list other causes of actual or apparent unilateral ventilation?

A.
- Pneumothorax
- Tension pneumothorax
- Haemorthorax/pleural effusion
- Bronchial obstruction
- Tracheobronchial disruption
- Unilateral parenchymal disease
- Pulmonary aspiration/consolidation/atelectasis
- Unilateral pulmonary bulla/emphysema
- Previous pulmonary surgery (pneumonectomy/lobectomy)
- Previous pulmonary tuberculosis.

**Tube obstruction**

A patient with an obstructed tube will exhibit obstructed breathing pattern (see Task 1) and other clinical signs of severe acute respiratory distress – dyspnoea, hypoxaemia, hypercarbia. If the patient is receiving mechanical ventilation, one or more alarms may be triggered e.g. high inflation pressure or poor (exhaled) tidal volume. Failure of oxygen/air supply to the ventilator may produce the same clinical findings as tracheal tube obstruction but a different alarm profile. If in doubt check gas supply connections, ventilator function and ventilator-to-patient circuit.

**Tracheal tube obstruction**

The causes of an obstructed tracheal tube are:

- Kink in tracheal tube
- Mucus plug/blood/secretions
- Narrowed lumen in non-reinforced nasotracheal tubes
- Biting, particularly with (wire spiral) reinforced tubes which become permanently deformed when compressed (see anecdote below)
- Obstruction of tube tip by side/posterior walls of lower airways.

Always go back to simple techniques. Use a manual bagging system (often termed an ‘anaesthetic’ or ‘physiotherapy’ circuit) to manually ventilate the patient – particularly those whose respiratory difficulty has arisen while on mechanical
ventilation. High resistance/inability to inflate the lungs suggest tube obstruction. The (recent) inability to pass a suction catheter down the lumen is also highly suggestive especially in long-term ventilation patients. In the non-emergency situation, a small fibre optic bronchoscope may be passed down the tube to visualise the nature and site of the obstruction. Sometimes an obstruction can be removed (e.g. by suction catheter). Sometimes it requires removal of the tube, manual ventilation (to reverse hypoxaemia and hypercarbia), followed by reintubation. The latter may be difficult due to vocal cord (and generalised airway) oedema. Appropriate preparations should be made. See the video demonstration below.

A neurosurgical patient, in ICU, started to bite on his reinforced tracheal tube when his sedation was reduced. Suction catheters could still be passed fully into the trachea with slight difficulty. Twelve hours later the patient suddenly became distressed and the ‘high pressure’ and ‘low exhaled minute volume’ alarms sounded on the ventilator. Manual bagging was unhelpful due to very high resistance and the patient’s SpO₂ fell quickly to 82%. The tracheal tube was removed and replaced by a standard (non-armoured) tracheal tube. Examination of the original tube showed a severely narrowed section where the wire spiral had been crushed by biting. This segment was completely obstructed by a plug of clot, fibrin and pulmonary secretions.

Tracheostomy tube obstruction

Causes:

- Plugging
- Abnormal position within the airway.
Tracheostomy tubes are shorter, more curved and more rigid than tracheal tubes. They rarely kink. They may become blocked with secretions/blood but often suctioning the tube easily solves this. Tracheostomy tubes with inner cannula have an advantage in this regard in that when blocked, the inner cannula (containing the obstructing plug) may be removed for washing, leaving the outer cannula in situ providing a clear airway. Such tubes are especially advantageous for critical care patients discharged to general wards.

Tracheostomy tubes may become obstructed when the distal opening becomes tightly applied to the side/posterior walls of the trachea or (rarely) the carina. Often problems with tracheostomy tubes are related to partial or complete displacement, which may be surprisingly difficult to detect.

**Tube displacement**

Tube displacement often constitutes a life-threatening emergency. Although it may be viewed as ‘bad luck’ or ‘an unavoidable accident’ this is often not the case and such adverse events should be viewed as avoidable. The frequency of tube displacement should be reduced by good medical and nursing practices (see below).

**Tracheal tubes**

The first step in management of tube displacement is to decide whether the patient can manage without the tube (see Tasks 1 & 2). If replacement of an orotracheal tube is required, appropriate preparation for a difficult intubation is strongly advised (see above).

**Tracheostomy tubes**

Tracheostomy tubes are usually more secure than tracheal tubes but, if displaced, may result in a very difficult situation. This is particularly so if the tracheostomy was performed less than 5–7 days previously and if the tracheostomy has been performed as a percutaneous technique. Again the option to leave the patient without a tube should be considered. If this course is pursued, and the acute concerns regarding oxygenation and ventilation have passed, the tracheostomy opening should be dressed to make it as ‘airtight’ as possible. This will facilitate more effective coughing.

If the tracheostomy is new (less than 5–7 days old), the track through the various layers of tissue in the neck may be lost, preventing simple replacement of the tube. Occasionally a gum elastic bougie is helpful in routing the tracheostomy tube back into the trachea through the (now disappeared) openings in the tissue plains of the neck. Such attempts should NOT be prolonged. Often it is simpler and safer to reintubate the patient with an orotracheal tube (see above). After reintubation, the tracheostomy should be sealed with an appropriate dressing and the tracheostomy procedure repeated electively later. With a more mature tracheostomy (more than 7 days old), it is often a simple matter to place a new tube through the mature (stable) track which forms between the skin and the trachea.
Another problem is that tracheostomy tubes may be displaced from the lumen of the trachea but appear to be in the ‘normal’ position when viewed externally. Any problem with breathing, ventilation or tracheal suctioning in patients with a tracheostomy must be considered seriously. Pre-emptive fibre optic assessment of the tube position and patency may be very useful. Sometimes if required the endoscope can be used to ‘railroad’ the tracheostomy tube back to the optimum position. Sometimes the best course of action is to remove the tracheostomy tube and reintubate as described above.

Q. What situations increase the risk of tracheal or tracheostomy tube displacement?

A.
- Insufficient numbers of appropriately trained nursing staff.
- Agitated patients/poor sedation.
- Failure to place tracheal tube in mid-trachea/tracheal tubes cut inappropriately short.
- Insecure/inappropriate tracheal tube fixation.
- ‘Drag’ on tracheal tube e.g. failure to support ventilator circuit.
- Major movements of patient – physiotherapy, proning, moving to other bed/trolley/operating table without appropriate care/stabilisation of the tracheostomy tube.

CONCLUSION

Appropriate management of the airway is the cornerstone of good resuscitation. It requires good judgment (airway assessment), skill (airway manoeuvres) and constant reassessment of both the patient’s condition and the efficacy of medical interventions. While complex procedures are sometimes life-saving and always carry the ability to impress the uninitiated, it is important to realise that the timely application of simple airway manoeuvres are often very effective and may avoid the need for further intervention.
SELF-ASSESSMENT

EDIC-style Type K

1. How can you clinically differentiate at the bedside between stridor and bronchospasm?
   A. Stridor is mainly inspiratory
   B. Bronchospasm is best heard in the end inspiratory phase
   C. Respiratory rate is characteristically low in patients with stridor
   D. Stridor is best heard through a stethoscope

2. If this man (see picture) required ‘invasive’ ventilation (using a tracheal tube), what problem would you anticipate?
   A. Difficulty with bag and mask ventilation
   B. Difficult tracheal intubation
   C. High risk of aspiration
   D. Corneal damage

3. Important steps to assure successful airway management (intubation) include:
   A. Elevation of the head (occiput)
   B. Flexion of the atlanto-occipital joint
   C. Skilled assistance
   D. Ensuring that a straight laryngoscope blade is used

4. Complications following the use of an oropharyngeal airway include:
   A. Gagging
   B. Vomiting
   C. Laryngospasm
   D. Worsening airway obstruction

5. What are the important determinants of the actual inspired oxygen concentration in a patient using a face-mask?
   A. Oxygen flow to the mask
   B. Patient peak inspiratory flow rate
   C. Patient respiratory rate (frequency)
   D. Tidal volume
6. Indications for tracheal intubation include:
   A. Obstructed airways
   B. Inadequate ventilation or oxygenation
   C. GCS <8
   D. Severe metabolic acidosis

7. Usual methods of ensuring optimal positioning for a tracheal tube in adults is to check that:
   A. Upper limit of the cuff is 1–3 cm below the vocal cords
   B. Lower limit of the cuff is 5–6 cm below the vocal cords
   C. End of the tube is as close as possible to the carina
   D. End of the tracheal tube is 3–4 cm above carina

8. An adult patient in the ICU is still hypoxaemic after a successful intubation of the trachea and, on auscultation, you think the breath sounds are diminished on the left side. What other (bedside) findings would support the diagnosis of unilateral bronchial intubation?
   A. Reduced expansion of left hemithorax
   B. PaCO₂ more than twice normal values
   C. Tube length 19 cm at the teeth
   D. High FiO₂ to maintain normal SpO₂

9. You suspect a partial tracheal tube obstruction in one of your ICU ventilated patients because of a gradual increase in airway resistance. What would you do to confirm your suspicions?
   A. Rule out non-endotracheal tube causes by taking a chest X-ray
   B. Immediately reintubate the patient
   C. Regard the successful passing of a suction catheter as evidence that partial tube obstruction can be ruled out
   D. Perform a bedside bronchoscopy

EDIC-style Type A

10. The inability to open up the mouth, after administration of anaesthesia drugs to facilitate tracheal intubation, could be caused by all of the following EXCEPT:
    A. Masseter muscle spasm
    B. Facial burns
    C. Scleroderma
    D. Oral albinism
    E. Post radiation fibrosis

11. Drugs to facilitate rapid (sequence) endotracheal intubation may include the following EXCEPT:
    A. Propofol
    B. Thiopentone
    C. Alfentanil
    D. Suxamethonium
    E. Pancuronium
12. Important factors for a fibre optic intubation include all of the following EXCEPT:
   A. Placing the tracheal tube on fibrescope prior to procedure
   B. Use of topical anaesthesia in nasopharynx
   C. Induction of general anaesthesia prior to procedure to avoid coughing
   D. Endoscopic identification of the tracheal rings
   E. Having a skilled assistant at hand

13. A 73-year-old female requires intubation prior to mechanical ventilation because of intracerebral haemorrhage and GCS of 5. After light sedation, and use of topical anaesthesia, you are not able to visualise the epiglottis or vocal cords, and two attempts to blindly pass the tube are unsuccessful. During the second attempt her oxygen saturation (SpO₂) has fallen from 97 to 82%. Which of the following procedures would be the most appropriate next step:
   A. Immediately ask for the intubating bronchoscope in order to perform a fibre optic intubation
   B. Ask for a laryngeal mask
   C. Immediately give muscle relaxation to facilitate intubation
   D. Perform an emergency cricothyroidotomy
   E. Withdraw the laryngoscope and assist her spontaneous ventilation efforts with mask and bag

14. The major indication for performing a cricothyroidotomy is:
   A. If two or more different methods to perform intubation are unsuccessful
   B. In patients with inability to move the neck
   C. ‘Cannot intubate, cannot ventilate’ situation
   D. If the physician in charge is inexperienced in intubation
   E. A patient with micrognathia

15. The best method to confirm the tracheal positioning of an endotracheal tube is:
   A. Reported visualisation of the tube entering through the vocal cords
   B. Chest wall movement during positive pressure ventilation
   C. Auscultation of the lungs
   D. An end-tidal CO₂ measurement or trace
   E. The presence of water vapour condensing in the breathing system (circuit)
Self-assessment answers

Type K

<table>
<thead>
<tr>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
<th>Q6</th>
<th>Q7</th>
<th>Q8</th>
<th>Q9</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. T</td>
<td>A. F</td>
<td>A. T</td>
<td>A. T</td>
<td>A. T</td>
<td>A. T</td>
<td>A. T</td>
<td>A. T</td>
<td>A. T</td>
</tr>
<tr>
<td>C. F</td>
<td>C. F</td>
<td>C. T</td>
<td>C. T</td>
<td>C. F</td>
<td>C. T</td>
<td>C. F</td>
<td>C. F</td>
<td>C. F</td>
</tr>
<tr>
<td>D. F</td>
<td>D. F</td>
<td>D. F</td>
<td>D. F</td>
<td>D. T</td>
<td>D. F</td>
<td>D. T</td>
<td>D. T</td>
<td>D. T</td>
</tr>
</tbody>
</table>

Type A

10. Answer D is correct
11. Answer E is correct
12. Answer C is correct
13. Answer E is correct
14. Answer C is correct
15. Answer D is correct
**PATIENT CHALLENGES**

An 18-year-old obese man is involved in a (witnessed) road traffic accident. He was the driver of a car observed crashing into a wall at approximately 80 km/hr. He was not wearing a seat belt and was ejected 10 m from the car. He received basic life support within seconds of the accident. Five minutes later, he arrives in the Emergency Department of the local hospital. His eyes are not open, he is making incomprehensible sounds and he is flexing to painful stimuli. His respiratory rate is 30 breaths/min and breathing is noisy. He is cyanosed and has a heart rate of 120 bpm and blood pressure 100/60 mmHg.

Q. What immediate action should be taken?

A. First an immediate assessment of airway and breathing must be performed and oxygen given. In view of the mechanism of injury it must be assumed that the patient has an unstable cervical spine. Protection of the cervical spine whilst performing any airway manoeuvre is paramount. Look and listen for signs of airway obstruction. Observe the respiratory rate, the pattern of chest movement and the presence of retraction of the suprasternal, supraclavicular and intercostal muscles. Auscultate for bilateral chest sounds.

**Learning Issues**

Assessment of the airway

Cervical spine injury

The patient is tachypnoeic and has signs of partial airway obstruction. Whilst avoiding neck extension, you attempt to open the mouth and elevate the jaw. Supplemental oxygen by tight fitting face-mask is provided and a cervical collar is fitted.

**Learning Issues**

Variable flow face-mask

Q. Is the triple airway manoeuvre indicated? Justify your decision.

A. The triple airway manoeuvre involves opening the mouth, elevating the mandible and extending the neck. While it may help to alleviate obstruction of the airway, in this case, neck extension must be avoided since there may be a cervical spine injury involved.

**Learning Issues**

Triple airway manoeuvre

The airway has been cleared with the insertion of an oropharyngeal airway and oxygen is being provided by a tight fitting face-mask. However the patient becomes apnoeic. There is no response to deep painful stimuli. You note clear fluid coming from the nostrils. Whilst preparing for intubation manual ventilation with a bag-mask is commenced.
Learning Issues

Oropharyngeal airway

Bag-mask ventilation

Q. What preparation should be made prior to intubating the patient?

A. Prepare the patient by reassessing the airway. Position the patient optimally. Ensure sufficient intravenous access.
Preparation of all equipment including a range of tracheal tubes, laryngoscopes and emergency airway equipment.
Prepare the drugs including anaesthetic agents, muscle relaxants, vasopressors and resuscitation drugs.
Prepare your assistant. The patient may have a full stomach and so an assistant to perform cricoid pressure is required. In view of the potential cervical spine injury, this is best performed as bimanual control of the neck. A dedicated (additional) assistant to perform manual in-line stabilisation is mandatory.

Learning Issues

Preparing for intubation

Cricoid pressure and BURP

Manual immobilisation – PACT modules on Multiple trauma and Patient transportation

Note Preparation is the key to successful intubation.

Q. What is the preferred method of tracheal intubation in this patient? Why? What would you do with the cervical collar?

A. Oral intubation with manual in-line stabilisation of the cervical spine is the preferred option. Nasal intubation is contraindicated because of apnoea – without breath sounds, it would be unlikely that a ‘blind’ technique would be successful and inserting a nasal tube under direct vision at laryngoscopy has no advantages over oral intubation. The presence of possible CSF leakage suggests basal skull fracture which is also a contraindication to nasal intubation. The anterior portion of the cervical collar should be removed/released to allow mouth opening and the application of cricoid pressure. Manual in-line immobilisation must be employed. In some hands, the use of a stylet within the tracheal tube may improve the chances of a successful intubation at the first attempt.

Learning Issues

Types of intubation
Q. Which drugs would you administer prior to intubation? Which muscle relaxants (neuromuscular blocking drugs) are appropriate and what are the possible side effects of the drugs?

A. The patient is unconscious and not responding to pain so hypnotic drugs may not be required. Caution should be taken to avoid rises in intracranial pressure associated with intubation in this patient with potential intracranial pathology. Many experts would give a judicious dose of an anaesthesia induction agent such as propofol. A muscle relaxant should be administered. Suxamethonium (succinylcholine) remains a safe choice for a rapid onset short acting depolarising muscle relaxant; however the potential side effects include tachycardia and hypertension due to autonomic stimulation or bradycardia following higher doses. Skeletal muscle contraction can result in high intraocular pressure, increased intragastric pressure, myoglobinuria, and hyperkalaemia. Intracranial pressure may also be increased. On balance, in this case, it is decided to use suxamethonium 100mg – given as an intravenous bolus.

**Learning issues**

Use of drugs in airway management

- **Note** Beware of the potential cardiovascular side effects of intravenous anaesthetic agents in trauma patients who may be hypovolaemic.

Feneck RO, Cook JH. Failure of diazepam to prevent the suxamethonium induced rise in intra-ocular pressure. Anaesthesia 1983; 38(2): 120–127. PMID 6829877


Your best laryngoscopy attempts reveal the view above with no visualisation of the larynx. You make one attempt to pass a gum elastic bougie ‘blindly’ into the trachea without success. You are able to manually ventilate the patient with 100% oxygen but the oxygen saturation is gradually falling to 94%.
Assessment of the airway

Q. Describe the view. What options are now available?

A. The view is described as Cormack and Lehane grade 4 (of a 1 to 4 scale of impaired visualisation of larynx). This situation is an example of ‘failure to intubate but able to ventilate’. This situation can rapidly deteriorate to the ‘failure to intubate—failure to ventilate’ if an inappropriate course of action is chosen. Unlike a patient anaesthetised for an elective surgical procedure, the option to attempt to awaken this patient is not available.

Q. What do you do next? Outline your sequence of responses.

A. Call for more experienced help.
Ensure optimal patient positioning.
Choose from adjuncts which include the gum elastic bougie (already tried), alternative laryngoscope blades, lighted stylet or video laryngoscopy.
Practitioners should use one or two of these adjuncts – it is not advisable to try each in turn!
If this fails to improve the view then avoid repeated attempts at intubation. Move on to the next step on the difficult airway algorithm.
Insert a laryngeal mask airway or intubating LMA.
Fibre optic intubation can be considered only if the operator is experienced.
If these manoeuvres fail or are inappropriate, consider cricothyroidotomy.

Link to http://www.nda.ox.ac.uk/wfsa/html/u09/u09_025.htm

Difficult Airway Algorithm

Laryngeal mask airway

Fibre optic intubation

Cricothyroidotomy

Fibre optic intubation is performed and the tracheal tube is inserted. Oxygen saturation is 100% and air entry is heard bilaterally. The position is checked using the fibre optic scope, the tracheal tube is secured and the patient is transferred to the intensive care unit. Ten minutes later the oxygen saturation falls to 80%.
Q. What is the most likely cause of this fall in oxygen saturation?

A. A frequent cause of decreased oxygen saturation following intubation is movement of the tracheal tube following (appropriate) insertion. The tube may be in either main bronchi or may have been displaced into the oesophagus.

Q. How may the diagnosis be confirmed?

A. Check for end-tidal CO₂ or identify the tube lying in the trachea by endoscopy. This will confirm that the tube is within the airway. The chest should be carefully examined to assess air entry and expansion. This may suggest endobronchial intubation which should be corrected immediately. Be aware that the signs may be misleading. The fact that the tube had previously been in the correct position does not rule out subsequent movement especially in the trauma situation. A chest X-ray should be performed to confirm tube position.

**Correct tube positioning**

**End-tidal CO₂ monitoring**

**Misleading signs of tube placement**

The tracheal tube has been misplaced into the right main bronchus in this case. This occurs more often in the difficult airway. The relief of actually securing the airway can lead to the tube being positioned further into the trachea than required.

Q. What are the other potential causes for a fall in oxygen saturation at this stage?

A. There are many potential causes for the falling oxygen saturation including:

- Pneumothorax or massive haemothorax
- Aspiration of gastric contents or blood from the upper airway
- Pulmonary contusion
- Pulmonary oedema
- Airway plugging
After three days in the intensive care unit the cuff on the tracheal tube develops a leak. The patient requires PEEP of 7.5 cmH₂O and FiO₂ of 0.5.

Q. How would you change the tracheal tube and what precautions would you take? What are the potential side effects of the method used to change the tube?

A. This patient has both a cervical spine injury and a difficult airway. It is not appropriate to remove the tube and assume that reintubation will be straightforward even with the aid of fibre optics. Reintubation may be more difficult given the possibility of cord/airway oedema. Consider changing the tube over a gum elastic bougie or airway exchange (ventilating) catheter. Be aware of the possible side effect of tension pneumothorax especially if the tip of the tube changer is positioned below the carina. Prepare for a formal tracheostomy or at least a cricothyroidotomy in the event of failure to secure the airway.

Changing the tracheal tube

Cricothyroidotomy

The patient’s respiratory function improves slowly but he remains neurologically obtunded with a Glasgow coma scale of 7. ICP monitoring and repeat CT scan fail to show evidence of intracranial hypertension but the CT appearances do suggest a significant cerebral hypoxic injury. By day ten following injury, he is on 40% oxygen, CPAP 3 cmH₂O with PS 10 cmH₂O.

Q. What are the arguments for performing a tracheostomy and when do you think the optimal timing should be?

A. There remains some debate in intensive care medicine over the topic of tracheostomies. This patient has suffered a significant head injury resulting in an alteration in level of consciousness. He also continues to require additional ventilatory support. Prolonged translaryngeal intubation may result in laryngeal or subglottic damage. A tracheostomy may (i) improve bronchial toilet, (ii) provide a more secure airway and (iii) be better tolerated than an orotracheal tube.

Indications for tracheostomy
Q. Outline the different methods of performing a tracheostomy and your preferred choice in this case?

A. Tracheostomy may be performed by several percutaneous techniques or a surgical tracheostomy may be performed. The identified relative contraindications to percutaneous tracheostomy in this patient include the presence of a cervical spine injury and the difficult airway. Other important factors include the possibility of bleeding, further anatomical abnormalities and the experience of the operator. These factors are becoming less critical with the greater experience in the performance of percutaneous tracheostomies.

**Percutaneous tracheostomy**

A surgical tracheostomy is performed in the operating theatre/room and the patient is returned to the intensive care unit. On transferring the patient from the portable transport ventilator to the intensive care ventilator, you note that the peak inspiratory pressure is over 40 cmH₂O. There appears to be little chest movement and air entry appears to be reduced on both sides of the chest. The saturation falls from 99% to 90%.

**Complications of tracheostomy**

Q. Describe the possible causes of this fall in saturation. Outline a systematic approach to confirm or exclude them?

A. Go back to first principles – A,B,C.

Is the tracheostomy tube in the trachea? Check for end-tidal CO₂. Place the patient on bagging circuit (breathing system) to oxygenate with 100% oxygen. How does it feel? What is your impression of chest compliance? Has the tube moved into a main bronchus? Look for bilateral chest expansion and listen for bilateral air entry. If there is any doubt regarding the position of the tracheostomy, the position should be checked with fibre optic bronchoscopy.

Does the patient have a pneumothorax? A Chest X-ray is the investigation of choice. Air entry may be decreased and the trachea deviated away from the side of a tension pneumothorax. Look for signs of subcutaneous emphysema. If a tension pneumothorax has occurred, immediate decompression with a 14G cannula in the 2nd intercostal space (mid-clavicular line) is required followed by a definitive thoracic drain.

Has haemorrhage into the airway occurred? The airway should be suctioned and a fibre optic inspection performed.

The position of the tracheostomy was checked by fibre optic endoscopy. The tracheostomy was too short and its position was such that the distal opening was occluded by the posterior tracheal wall. Although a standard tracheostomy may be suitable for the majority of patients there are some patients where problems can occur. A tracheostomy with an adjustable flange was reinserted and positioned optimally using fibre optic endoscopy.
**On reflection**, the patient has many complications of management of the difficult airway. The above scenario may have been due to the patient coughing against the tube or due to bronchospasm. Some of the complications such as the endobronchial intubation were avoidable.

There are numerous complications of tracheostomy ranging from minor haemorrhage to death. Pneumothorax and pneumomediastinum are not uncommon and should be considered early in a situation such as this. Tension pneumothorax can be fatal if not treated rapidly. Tracheostomy tubes may be misplaced into the anterior mediastinum resulting in massive subcutaneous emphysema or may be occluded by the posterior tracheal wall or at the carina.

There is no doubt that the secret of success in managing the difficult airway lies in becoming skilled in a wide range of techniques. Ensure that you update your skills on a regular basis. If one technique fails, move on to the next stage of the algorithm rapidly. Avoid the temptation to use increased force and neck extension especially in this case where there is potential to cause or exacerbate a spinal cord injury. Seek more experienced advice early. Always ensure that oxygenation is maintained and have the necessary equipment readily available to perform a trans-tracheal puncture, by needle or other cricothyroidotomy approach, in the ‘failure to intubate–failure to ventilate’ scenario.