Royal College of Anaesthetists

Difficult Airway Society

Tayside Mastery Learning Programme

Pre-oxygenation and Basic Airway Management

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LEARNING OUTCOMES

By reviewing this pack, a trainee should gain an understanding of the following:

1. the ethos of airway management.
2. the principles of pre-oxygenation and apnoeic oxygenation.
3. the principles of basic airway management and bag–valve–mask ventilation.

1: THE ETHOS OF AIRWAY MANAGEMENT

The management of the airway is a core skill within anaesthesia and our expertise in it is one of our most defining roles. The ability to open, maintain and provide mask ventilation to a patient are the most basic, yet the most essential skills in airway management.

Mortality and serious morbidity secondary to poor airway management remain relevant in world anaesthesia, including the UK; hence, effective management of every airway – straightforward, difficult or failing – is crucial to the provision of safe and successful anaesthesia. This involves more than the acquisition of technical skills in the use of both basic and advanced airway equipment. It requires an ability to recognise different clinical scenarios and to translate that information into a sensible **airway management strategy**, involving the whole team.

Our goal is safe airway management through provision of airway patency; maintenance of oxygenation and ventilation; prevention of iatrogenic trauma; and recognising and adapting to predicted difficulty through the principles of:

- airway management in the RIGHT PLACE: a suitable location with appropriate monitoring and assistance.
- airway management with the RIGHT EQUIPMENT: using equipment with which one is familiar.
- airway management by the RIGHT PERSON: identifying our own limitations, anticipating the need for assistance in managing predicted difficulty and recognising the need for early, more expert help in difficulty that was unanticipated.
- airway management with the RIGHT MIND: maintaining good situational awareness, avoiding cognitive overload and task fixation through the implementation of checklists and cognitive aids/algorithms, and utilisation of good communication.

2: PRINCIPLES AND PRACTICE OF PRE-OXYGENATION AND APNOIEC OXYGENATION

Essential theory: physiology

Almost all oxygen is carried in the blood in combination with haemoglobin (Hb). On average, arterial blood contains approximately 200 ml/l. Assuming a cardiac output of 5 l/min, this equates to 1000 ml of oxygen being delivered to the tissues each minute. At rest, the average oxygen consumption is approximately 250 ml/min. During normal breathing, the lungs continually oxygenate the venous blood entering the lungs. When a patient stops breathing (apnoea), the lungs come to rest at a volume known as the functional residual capacity (FRC) and is generally about 30 ml/kg. During apnoea, the FRC provides the reservoir for ongoing oxygenation of the blood. When breathing air, the gas present in the FRC is composed of approximately 14% oxygen, 5% carbon dioxide and 71% nitrogen. In the average 70-kg patient, this equals less than 300 ml of oxygen (14/100 × 30 × 70 = 294 ml). Therefore, when a patient becomes apnoeic, the oxygen in the lungs is rapidly absorbed and the blood oxygen content falls resulting in hypoxaemia after approximately 60 seconds or less. This time to hypoxaemia is affected by the composition of gas within the FRC, the volume of FRC and oxygen consumption of the patient.

Pre-oxygenation is the principle in which the percentage of oxygen within the FRC is increased in anticipation of apnoea. This is done by giving the patient an increased inspired oxygen concentration and replacing the nitrogen within the FRC with oxygen (a process also known as de-nitrogenation). If done correctly, this can increase the volume of oxygen available during apnoea significantly and prolongs the time to hypoxaemia. This is particularly important during the induction of anaesthesia, as it provides a greater safety margin in the event that the patient has an expected or unexpected problem during airway management (see **Fig 1** and **Fig 2**).

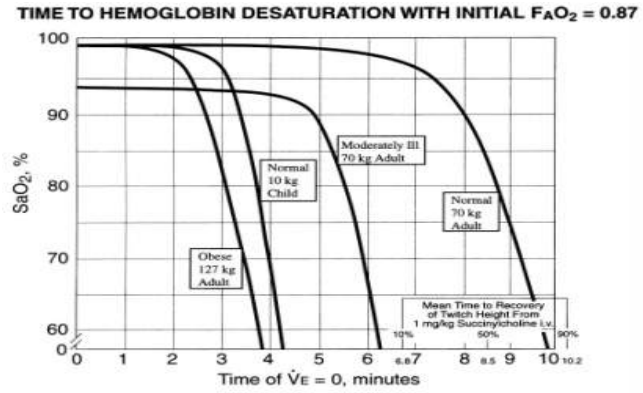

Fig 1: Time to haemoglobin desaturation after pre-oxygenation.

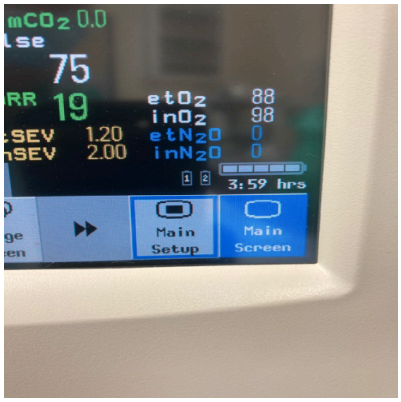

Fig 2: Inhaled/exhaled gas monitoring. (Photograph: authors own)

Using gas sampling equipment, anaesthetists can measure the amount of oxygen they deliver into the patient, but also the amount of oxygen they are breathing out. Therefore, one can assess the efficacy of ones attempt to pre-oxygenate the patient by measuring the amount of exhaled oxygen. Through pre-oxygenation, we aim to achieve an end-tidal fraction oxygen concentration (ETO_2) of greater than 0.8; this means a large component of expired gas is oxygen rather than nitrogen. In our 70-kg patient, there is now a reserve of 1890 ml of oxygen for consumption while the patient is apnoeic. This ETO_2 target of > 0.8 may not be achievable in uncooperative patients, those with rapid oxygen consumption rates or significant ventilatory or pulmonary perfusion deficits.

If the mask-to-patient seal is not complete, then room air will be entrained and the patient will not receive 100% oxygen; thus, reserves will be affected.

In the absence of gas analysis, effective pre-oxygenation can be achieved by:

- 3 minutes of tidal volume breathing with good face mask seal using 100% O_2
- 1 minute of vital capacity breathing with good face mask seal using 100% O_2.

In addition to pre-oxygenation, one can extend the apnoea time by ensuring a continued supply of oxygen into a patient's airway up until a more definitive airway is secured (i.e. up to and ideally during laryngoscopy). The uptake of oxygen at the alveolar level ensures a constant stream of oxygen delivery, provided the airway is patent. This can be achieved by:

- delivery of oxygen through the continued application of a well-fitted anaesthetic mask until laryngoscopy

in addition to:

- delivery of low-flow oxygen via nasal prongs during laryngoscopy
- delivery of high-flow oxygen via nasal prongs during laryngoscopy.

Indications

Ideally all patients should undergo preoxygenation prior to induction of general anaesthesia because of the risk of apnoea and subsequent desaturation. This ensures optimal patient safety but also can increase "thinking time" and improve procedural performance of the anaesthetist in the event of

unanticipated difficulty. Some patients (such as children or uncooperative adults) may be non-compliant with pre-oxygenation so it may be pragmatic to avoid it, and instead gain rapid control of the airway once asleep. Such a decision should be made by a senior anaesthetist. Some patients are at particular risk of hypoxaemia during apnoea, this may be a result of a reduced FRC, an increased rate of oxygen consumption, or both. Examples are illustrated in the table below.

Condition	**Example**
Predicted prolonged apnoea time	Difficult airway (e.g. fixed cervical spine)
Underlying ventilation/perfusion mismatch	Pneumonia Hypotension
Reduced FRC	Obesity Pregnancy
Increased oxygen requirement	Paediatrics/neonates Pregnancy Sepsis

Contraindications

Patient refusal: this is generally related to mask phobia, mask discomfort etc.

Equipment

Face mask: this should be fitted appropriately to the patient, creating a seal around the nose and mouth, without pressure on the eyes, thus allowing delivery of a high concentration of oxygen without entrainment of air/nitrogen into the delivered mask.

Humidification filter: this will warm and humidify delivered gas.

Source of oxygen: cylinder, piped gas from wall mounted oxygen port or anaesthetic machine.

Breathing system: self-inflating "Ambu" bag or anaesthetic breathing circuit. The bag component will move with respiration if an effective mask-patient seal is in place.

End-tidal gas monitoring/capnography: this will allow measurement of ETO_2 to assess the efficacy of the procedure and will also give an indication of the quality of the mask–patient seal through demonstration of a clear "square wave" capnography trace.

Communication with patient

Explaining the procedure to the patient can markedly reduce patient anxiety and acceptance of a well-sealed or "snug" mask on the face.

In some patients a complete seal can be difficult to achieve (particularly the elderly, edentulous or patients with facial hair) and may require gentle adjustment, including holding the cheeks up to the mask. A small number of patients will struggle to tolerate the face mask because of anxiety or claustrophobia; one way to improve this is to get the patient to hold the mask themselves with our support.

Preparation and procedure for pre-oxygenation

1. **Patient consent**
   - Explain the technique and reasons for preoxygenation in advance so they know what to expect.

2. **Assistance**
   - Ensure that you have an adequately trained anaesthetic assistant.

3. **Monitoring**
   - Attach standard anaesthesia monitoring (SpO_2, ECG, NIBP) to the patient.
   - Ensure that capnography is attached to the breathing circuit at the HME filter.

4. **Patient positioning**
   - Place the patient in a semi-recumbent position as this more efficient for pre-oxygenation than lying the patient supine as a result of positional effects on FRC.
   - The "sniffing" position is ideal. An imaginary horizontal line taken from the patient's tragus should be higher than the patient's sternum.
   - Ensure that the patient is comfortable and the head is well supported with pillows.

5. **Equipment**
   - Ensure an appropriately sized face mask is used.
   - Use HME filter within the breathing circuit.
   - Check that the APL valve is fully open and start the oxygen supply (minimum flow in adults of 6 l/min of 100% oxygen).

6. **Procedure**
   - Assemble circuit, HME, face mask apparatus.
   - Turn on oxygen to 6–8 l/min.
   - Gently place mask on face ensuring comfort and avoiding compression of the eyes/soft tissues.
   - Ensure an adequate seal – visualise the bag moving with respiration.
   - Observe capnography for a trace.
   - Observe the fraction of expired oxygen concentration.

7. **Assess and adjust**
   - Ensure an adequate seal of the face mask. This is confirmed by movement of the bag and an $ETCO_2$ trace.
   - Adjust mask position/seal if capnography trace not attained**.**

- Assess ETO_2 value and trend**.**
- If suboptimal ETO_2 or slow rate of rise: encourage deep inspiratory efforts (vital capacity breaths) and/or add a small amount of continuous positive-end expiratory pressure (CPAP).

3: THE PRINCIPLES OF SKILL IN BASIC AIRWAY MANAGEMENT

Basic airway management is the technique used to open an airway, ensuring patency, to administer gases during patient spontaneous ventilation, support oxygenation and ventilation in inadequate respiration, and to provide positive pressure ventilation during apnoea. The most basic way to maintain an airway and allow either spontaneous or assisted ventilation is by using both hands to hold a face mask on the patient's face to maintain an airtight seal. The airway is kept open to allow unobstructed respiration if the patient is breathing spontaneously. In an apnoeic patient, an assistant can squeeze the reservoir bag to achieve positive-pressure ventilation. Vigilance is necessary to detect airway obstruction. Alternatively, one hand can be used, freeing up the assistant to do other tasks. In addition, airway adjuncts, oropharyngeal and nasopharyngeal airways, can be used to enhance airway patency.

Essential theory: anatomy of the airway

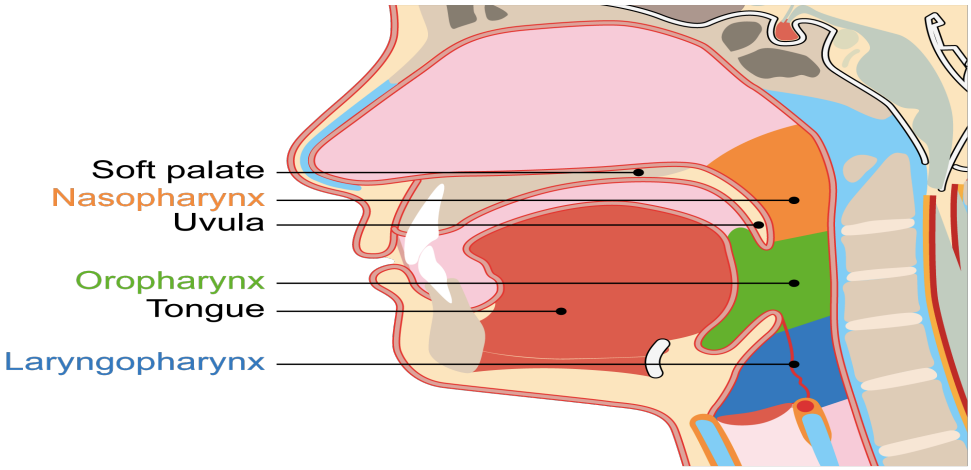

Fig 3: Anatomy of the airway
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The pharynx is the cavity that connects the nose and the mouth to the larynx and the oesophagus. It is divided into three sections: the nasopharynx, the oropharynx and the laryngopharynx.

The nasopharynx runs from the back of the nasal cavity down the posterior aspect of the soft palate.

The oropharynx runs from the uvula (a finger-like projection at the posterior aspect of the soft palate) to the epiglottis. The oropharynx contains anteriorly the palatoglossal arch, and posteriorly the palatopharyngeal arch. Between the two arches lie the tonsils. Just above the epiglottis is a fold called the vallecula; this where the blade of the laryngoscope is placed during laryngoscopy.

The laryngopharynx runs from the epiglottis to the cricoid cartilage, and contains the vocal cords.

Essential theory: physiology of obstruction

To understand simple airway management, one must understand simple airway obstruction. Collapse of the upper airway is common during anaesthesia; hence the reason why upper airway maintenance is a fundamental skill. Obstruction can occur for many reasons, but the most common is anaesthesia itself, where the loss of pharyngeal tone essentially produces a collapsible segment of the airway.

The upper airway is a framework of bone and cartilage with attached soft tissue from the nose to the larynx. Where not supported by bone, the airway can collapse once the muscle tone, that provides a degree of support, reduces with anaesthesia. Collapse will occur at points of narrowing and flaccidity, and can be additionally affected by anatomical pathology (e.g. tonsillar hypertrophy, tumour). The narrowest, most compliant section of the airway is within the pharynx. This is essentially a mobile segment between two rigid structures (nose/mouth and trachea).

Supine positioning increases the tendency to obstruct as the tongue and soft palate move posteriorly, causing additional narrowing of the palatal airway. Excessive neck flexion is also unfavourable.

To provide anatomical advantage in maintaining the airway we can:

- position in the 'sniffing air' position: lower cervical flexion, upper cervical extension with extension of the head on the neck ("flextension").
- lift the chin: increasing pharyngeal dimensions by tensioning pharyngeal muscles.
- displacing the mandible forward: pulling the tongue/soft palate forward, thus increasing airway calibre retropalatally.
- place oral or nasopharyngeal airways that bypass the obstruction in addition to the above.
- We can also apply positive airway pressure to the upper airway in order to pneumatically splint it at the collapsible segment.

To provide a patent airway, one must know how to recognise an obstructed one by the presence of:

- see-saw or paradoxical breathing.
- suprasternal, intercostal and/or subcostal indrawing.
- additional noises or silence.
- absence of face mask condensation on expiration.
- inadequate or absent capnography trace.

Indications

Basic airway management is indicated in the presence or anticipation of airway obstruction of whatever cause: this is everyone having a general anaesthetic.

Contraindications

There are no contraindications to basic airway management. Some caution is required in positioning patients with neck pathology.

Equipment

For the provision of safe airway management, it is necessary to assemble appropriate equipment and ensure all available resources are in good working order. An experienced and skilled assistant +/– competent supervisor is required for all episodes of airway management.

- Source of supplementary oxygen.
- Source of suction.
- Appropriately sized oropharyngeal airways (also nasopharyngeal airways but these are used infrequently in anaesthesia).
- Hudson mask or anaesthetic face mask.
- Equipment necessary for provision of positive-pressure gas delivery (Ambu bag or anaesthetic circuit).

Communication with patient

The patient should be informed that you are going to handle their airway. Initial movements in positioning and in chin lift/jaw thrust should always be gentle as these can be stimulating in a lightly anaesthetised patient.

Preparation and procedure

1. Patient and clinician preparation: ensure that equipment is available and in anaesthesia settings, pre-oxygenate as above.
2. Patient position: positioning of the patient is key prior to airway management. Patients are anaesthetised in the supine position with a head up tilt. Looking from the side, a horizontal line from the tragus should be at a greater height that the patient's sternum. In obese patients, additional equipment or pillows are required to achieve this position.
3. Open the airway before it obstructs: using both hands, one can gently pull the face up 'into the mask' rather than pushing the mask into the face. Fingertips should rest on bony structures, taking care not to compress soft tissues with either mask (on eyes/nose) or hands (submandibular tissue compression can worsen obstruction). Control of the mask and possible hand positions are shown in **Fig 4** for using both or one hand. Subtle adjustments can make a big difference – this is the skill of the anaesthetist and is one that develops with practice and experience.

Fig 4: A variety of hand grips, as described. (Photographs: author's own)

4. Assess the airway: if respiration is preserved, signs of a clear airway should be sought (e.g. mask misting, smooth respiratory mechanics, square wave capnography). If apnoeic, supply positive pressure and assess signs of a clear airway.

5. Continued assessment and adjustment: the patency of the airway and the efficacy of oxygenation and ventilation provided needs to be continuously assessed until a more definitive airway is secured if this is planned.

Pre-Oxygenation & Basic Airway Management Checklist Date:

Trainee name: Tutor:

Step	1st attempt	2nd attempt
Pre-procedure		
Ensures trained assistant & senior supervision		
Confirm airway plan with anaesthetic assistant		
Ensures appropriate airway equipment available		
Full monitoring including capnography		
Ensures patent IV cannula (unless inhalational induction)		
Open APL valve and start O_2 supply		
Procedure: Pre-oxygenation		
Position the patient appropriately		
Create an adequate seal of the face mask		
Assesses seal and adjusts accordingly		
Pre-oxygenate to $ETO_2 > 0.8$		
Procedure: Basic Airway Management		
Applies appropriate airway manoeuvres as patient loses consciousness		
Combines head tilt, chin lift (1 or 2 handed) – avoiding compression of soft tissue and eyes		
Ventilates the patient when respiratory effort ceases (1 or 2 handed)		
Uses additional manoeuvres or airway adjuncts as required – jaw thrust, oropharyngeal airway		
Continuously assesses efficacy of ventilation – chest rising, $ETCO_2$, absence of leak		
Post-procedure		
Documentation of airway management		
Throughout		
Appropriate communication with assistant & patient		
Aware of patient condition/vital signs		

Comments