Chapter 1

Airway management

Content

In emergency care, airway management is an essential first step as a means of achieving both oxygenation and ventilation. Failure to manage and maintain the airway can lead to neurological dysfunction and even death within minutes.[1] This chapter discusses the concept of a stepwise approach to airway management and provides the rationale for the airway interventions currently available to the paramedic.

Definition of airway management

Airway management may be defined as the provision of a free and clear passageway for airflow. Obstruction of the airway may be partial or complete and may occur at any level from the nose to the trachea. In the unconscious patient, the most common site of airway obstruction is at the level of the pharynx[2] and this obstruction has usually been attributed to posterior displacement of the tongue caused by reduced muscle tone. However, the cause of airway obstruction is often the soft palate and the epiglottis rather than the tongue.[3,4] Obstruction may also be caused by vomit or blood, swelling of the airway (e.g. anaphylaxis), a foreign body, or laryngeal spasm.

Concept of a stepwise approach

Airway management techniques range from basic manual manoeuvres to the more complex techniques of tracheal intubation and cricothyroidotomy. Each technique comes with its own inherent risks and it is essential that the paramedic is aware of the problems and limitations of each technique. It is advocated that a stepwise approach that leads from the least invasive to the most invasive technique be adopted.[1] The paramedic may choose to miss out certain steps based upon the needs of the patient, but a risk-benefit analysis should be undertaken to ensure that the most appropriate airway management technique is employed. It should be noted that measurement of airway adjuncts only provides a starting point for deciding on the appropriate size; it is essential to assess the effectiveness of any airway manoeuvre once undertaken.

Scenario

You are called to attend a 37-year-old female patient in cardiopulmonary arrest. On arrival you find that the patient is in the third trimester of pregnancy lying supine on the floor. What anatomical and physiological changes occur during pregnancy that may affect your airway management strategy? How would you manage the patient's airway?

Basic anatomy of the airway

See Figure 1.1.

Safe airway management requires sound knowledge of the relevant anatomy. This section provides an overview of the nose, pharynx, larynx, trachea and main bronchi; the practitioner is advised to refer to an appropriate anatomy text book for a deeper description of the airway.

Nose

The nose can be divided into external and internal portions. The external portion provides a supporting structure of bone and cartilage for the overlying muscle and skin; it is lined with a mucous membrane. The bony framework of the external nose is formed by the frontal bone, nasal bones and maxillae.

The internal portion lies inferior to the nasal bone and superior to the mouth and contains both muscle and a mucous membrane. It is worth remembering that the internal nares extend in an anterior-posterior direction, especially when inserting a nasopharyngeal airway.

Mouth

The mouth is not strictly a part of the airway, but as many airway management interventions involve the mouth, it is worth reviewing basic anatomy. The mouth is formed by the cheeks, hard and soft palates, and the tongue.[5] The lips surround the opening to the mouth and each lip is attached to its respective gum by the labial frenulum. The vestibule is the space between the cheeks or lips, and the teeth. The roof is formed by the hard and soft palates, whilst the tongue dominates the floor. The anterior portion of the tongue is free but connected to the underlying epithelium

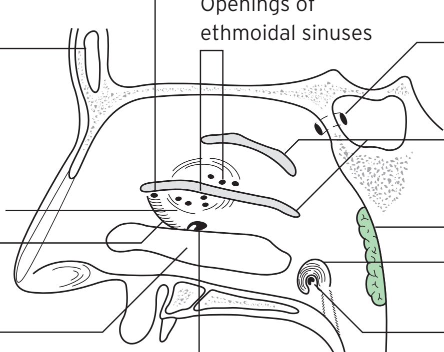

Figure 1.1 Lateral wall of nasal cavity. Reproduced from Faiz, O. and Moffat, D. *Anatomy at a Glance*, 2nd edn, copyright 2006, with permission of Blackwell Publishing.

by the lingual frenulum. The border between the mouth and the oropharynx extends from the dangling uvula to the base of the tongue.[6]

Pharynx

The pharynx is divided into three anatomical sections; the nasopharynx (extending from the internal nares to the posterior edge of the soft palate), the oropharynx (extending to the base of the tongue at the level of the hyoid bone) and the laryngopharynx (extending to the opening of the oesophagus).

Larynx

See Figures 1.2 and 1.3.

This is a very important structure in terms of airway management and it is essential to know the anatomy in depth. Basic anatomy is outlined here but it is recommended that revision should be undertaken with an appropriate anatomy text (see reference 5).

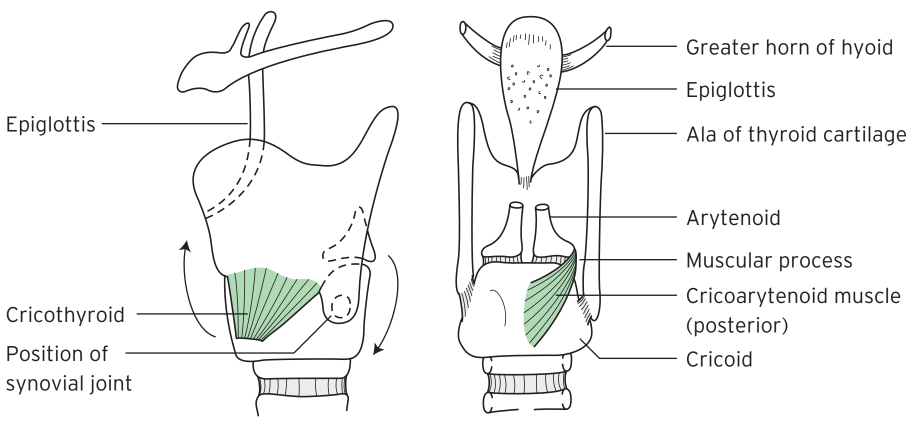

Figure 1.2 Cartilages of the larynx. Reproduced from Faiz, O. and Moffat, D. *Anatomy at a Glance*, 2nd edn, copyright 2006, with permission of Blackwell Publishing.

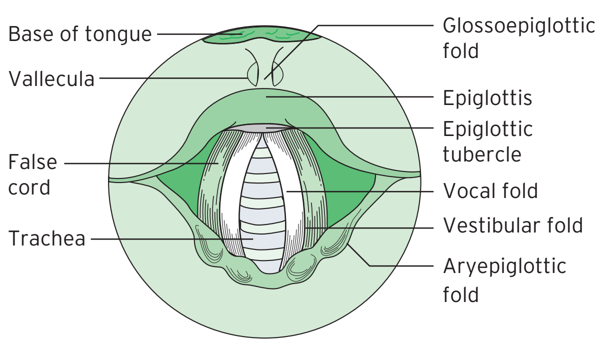

Figure 1.3 Larynx as viewed through a laryngoscope. Reproduced from Faiz, O. and Moffat, D. *Anatomy at a Glance*, 2nd edn, copyright 2006, with permission of Blackwell Publishing.

The larynx consists of nine cartilages; three paired and three single, as described below.

The epiglottis projects above the glottis and protects the larynx during swallowing. The thyroid cartilage forms most of the anterior and lateral surfaces of the larynx and tends to be more prominent in men. The cricoid cartilage is the ring-shaped cartilage that connects the larynx to the trachea. The three paired cartilages are found within the interior structure of the larynx and are the arytenoids, corniculate and cuneiform cartilages.

Trachea

See Figure 1.4.

The trachea is approximately 11–12 cm long and 2.5 cm in diameter. It is held open by 'C' shape cartilage, which is open posteriorly to allow for extension of the oesophagus during swallowing. The trachea bifurcates into the left and right main bronchi around the level of the 5th thoracic vertebra. The right main bronchus is

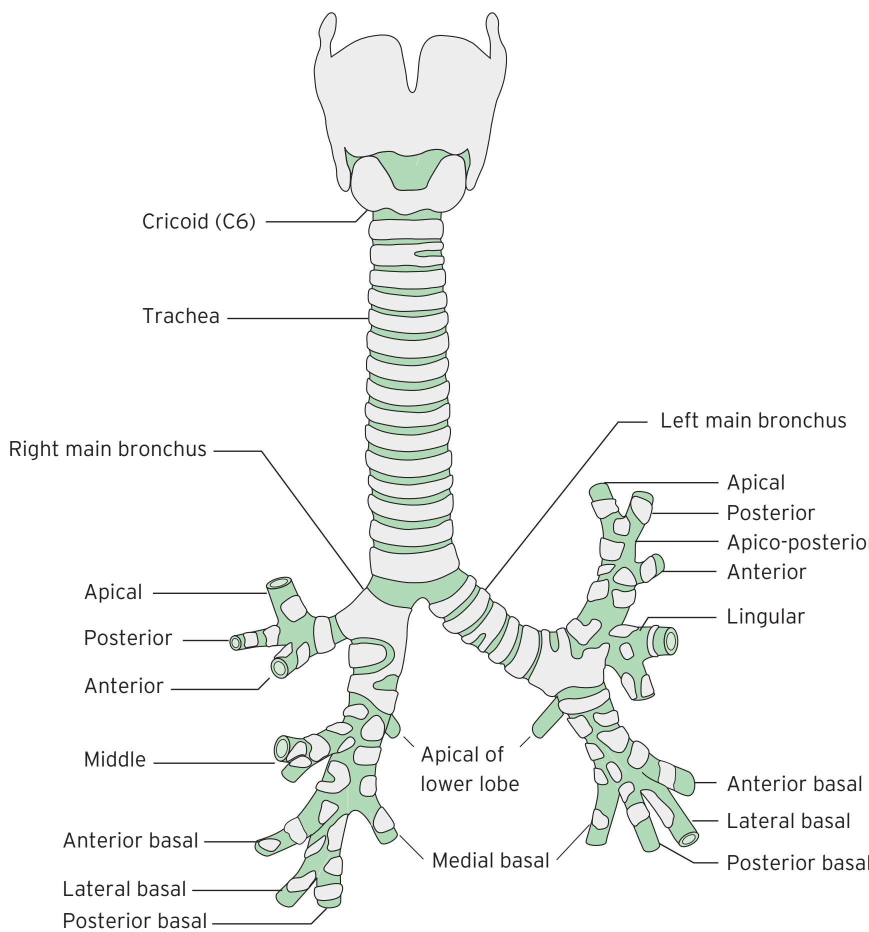

Figure 1.4 Trachea and main bronchi. Reproduced from Faiz, O. and Moffat, D., *Anatomy at a Glance* 2nd edn, copyright 2006, with permission of Blackwell Publishing.

larger in diameter than the left and extends at a steeper angle – an endotracheal tube that has been inserted too far is most likely to locate itself in the right side, as are foreign body obstructions.

Basic airway management manoeuvres

Head tilt and chin lift

This manoeuvre has been the mainstay of basic airway management for nearly 50 years with few changes advocated since the early 1960s. The rescuer's hand is placed on the patient's forehead and the head gently tilted back; the fingertips of the other hand are placed under the point of the patient's chin, which is gently lifted to stretch the anterior neck structures (Figure 1.5).

Jaw thrust

The jaw thrust is recommended where there is a risk of cervical spine injury but it may be used electively on any patient. Where there is no risk of spinal injury, the manoeuvre may be applied on its own or in conjunction with a head tilt manoeuvre.

The jaw thrust brings the mandible forwards and relieves obstruction by the soft palate and epiglottis. The practitioner places their index and other fingers behind the angle of the mandible and their thumbs on the mandible itself (Figure 1.6). The thumbs gently open the mouth whilst the fingers are used to apply pressure upwards and forwards. This movement causes the condyles of the mandible to sublux anteriorly in the temporomandibular joints. This displaces the mandible and tongue anteriorly, thereby clearing the airway.[7]

Figure 1.5 Head-tilt, chin-lift.

Figure 1.6 Jaw thrust.

THINK

Is there any circumstance where it would be permissible to perform a head tilt and chin lift manoeuvre in a patient with suspected cervical spine injury?

Basic airway adjuncts

Nasopharyngeal airway

See Figure 1.7.

The nasopharyngeal airway (NPA) is a simple airway adjunct that is used by a number of different healthcare disciplines. It has advantages over the oropharyngeal airway (OPA) in that it can be used in the presence of trismus, an intact gag reflex, or oral trauma.[8] Despite these advantages, the NPA is used less frequently than the OPA.[9,10]

Figure 1.7 Nasopharyngeal airways.

Figure 1.8 Bevel of NPA against the septum.

The NPA is designed to relieve soft tissue upper airway obstruction in a patient requiring airway support. The tube follows the natural curvature of the nasopharynx and extends to the posterior pharynx below the base of the tongue where it separates the soft palate from the pharynx. The distal end is bevelled to facilitate placing of the tube; the bevel should be placed against the nasal septum (Figure 1.8).

Sizing of an NPA

Traditional methods of sizing have tended to compare the NPA with the patients little finger or the size of their external nares; these methods are based on anecdote rather than evidence and are likely to be flawed. Both methods place emphasis on the diameter of the tube rather than the length despite an earlier study clearly showing that the length of the tube was more important than the diameter.[11] This study suggested that the tube should lie within 1 cm of the epiglottis. If too short the airway would not separate the soft palate from the posterior wall of the pharynx and if too long would enter either the larynx and stimulate laryngeal reflexes, or enter the vallecula with the inherent risk of obstructing the airway.

One small study has shown that neither of the traditional methods for measuring the NPA correlated with the nasal anatomy of the subject, so are unreliable.[12] A clear correlation between patient height and their nares–epiglottis length has been demonstrated[11] so it is perhaps more sensible to base NPA size on the patient's height and sex. In the absence of a more accurate measurement, it is recommended that a size 6 (130 mm length) be used for an average female and a size 7 (150 mm length) for an average male.[8,12] Longer or shorter lengths may be considered for patients who are taller or shorter than average.

Once the initial choice has been made the NPA should be measured to ensure that only the correct length is inserted. A reasonable way of ascertaining this is to measure from the tip of the nose to the tragus of the ear. There is sufficient anatomical correlation for this to prove reliable although checks to ensure correct placement should be undertaken afterwards. When the length has been ascertained, the safety pin should be inserted into the proximal end of the NPA at the maximum point of insertion; this will prevent the NPA from being inserted too far into the pharynx and possibly into the oesophagus. For example, if a size 7 (150 mm) had been selected and the measure from the tip of the nose to the tragus was 145 mm, the pin should be placed 5 mm distal to the flange of the NPA. The safety pin is not there to prevent loss of the NPA into the external nares. When inserting the safety pin, place to the side of the NPA to allow free passage for suction catheters if required.

Contraindications

A commonly taught contraindication to the use of an NPA is a potential or known basal skull fracture. Two published case reports of an NPA being inserted through a fractured cribriform plate into the cranial vault[13,14] may have been responsible for the development of this contraindication and it has been propagated by the Advanced Trauma Life Support Manual and courses. It is difficult to know whether these were isolated occurrences or whether further reports are less likely as it is no longer a novel complication, plus there may be a tendency to under report clinical errors.[15] The consensus appears to be that NPA placement may be necessary, even where relative contraindications exist, to avoid sub-standard airway management in patients with suspected or apparent base of skull fracture.

Complications

The most common complication is bleeding, which may cause serious airway obstruction if not managed. Blood tends to coagulate in the trachea and will form a solid occlusion to the passage of air. Patient positioning may help if bleeding does occur and suctioning will also be of benefit, although it is possible that suctioning may not be sufficient to maintain a clear airway.

If the bleeding is in the anterior portion of the nose, consider use of a tampon to stem the flow. If in the posterior portion of the nose, it may be necessary to insert a device such as a urinary catheter so that the balloon can be inflated to prevent aspiration of blood. Any practitioner who inserts an NPA must have a contingency plan for managing haemorrhage should it occur.

Necrosis of the anterior aspect of the nose may also occur if the diameter of the NPA is too large. If there is evidence of blanching around the external nares the NPA should be removed and a smaller one inserted. Necrosis will commence within about 20 minutes of the occlusion of blood supply and it is very difficult to cosmetically alter any damage.

Equipment required

- Range of nasopharyngeal airways
- Water-based lubricant
- Devices to arrest haemorrhage in both anterior and posterior portion of nose should it occur.

Technique for insertion

Procedure	Additional information/rationale
1. Select appropriate size, 7.0 as a starting point for an average adult male and 6.0 for an average adult female.	
2. Once the selection has been made, measure from the tip of the nose to the tragus of the ear. Insert safety pin to mark the maximum depth of insertion (this should be at the proximal end of the NPA).	If too short the airway would not separate the soft palate from the posterior wall of the pharynx; if too long may enter either the larynx or vallecula where the airway could become obstructed.
3. Where no risk of cervical spine injury exists, hyperextend the head and neck.	Stretches the anterior neck structures to relieve obstruction of the soft palate and epiglottis.
4. Lubricate the exterior of the tube with a water-soluble gel.	Minimises trauma during insertion.
5. If there is no obvious nasal deformity, it is recommended that the right nostril be used.[12]	The bevel of the NPA is designed to cause less trauma to the mucosa when inserted into the right nostril.
6. Where deformity exists, the most patent nostril should be selected.	

Procedure	Additional information/rationale
7. If inserting into the left nostril the bevel is placed alongside the septum and the airway rotated through 180° when it enters the nasopharynx.	To minimise trauma to the internal nares.
8. Insert the tube into the selected nostril and follow the nasal floor parallel to the mouth. It is imperative that the airway is not pushed in a cephalad direction.	This ensures correct location and reduces risk of cranial insertion where basal skull fracture exists.
9. Avoid pushing against any resistance. If resistance is felt, remove the airway, review technique and reinsert using the other nostril.	Pushing against resistance may cause bleeding and kinking of the NPA.
10. Verify appropriate position by listening for clear breath sounds and looking for chest rise and fall. Air may also be felt at the proximal end of the airway in the spontaneously breathing patient.	Ensures correct placement.
11. Check to make sure there is no blanching of the patient's nostrils. If there is, remove NPA and select a smaller diameter.	Prevents necrosis of the tissues.

Oropharyngeal airway

See Figure 1.9.

Oropharyngeal airways (OPA) are available in sizes suitable for neonate (00) to large adult (4). It is a curved plastic device designed to follow the curvature of the palate. It works to keep the tongue away from the posterior pharynx and to separate the soft palate from the pharyngeal wall. The OPA is designed to be used in unconscious patients requiring airway support and should only be inserted in those patients who have absent laryngeal and glossopharyngeal reflexes.[16] Use of an OPA in patients with these reflexes intact may cause vomiting or laryngospasm.

The oropharyngeal airway can become obstructed at three possible sites:[17] part of the tongue can occlude the end of the airway; the airway can lodge in the vallecula; and the airway can be obstructed by the epiglottis.

Sizing of an OPA

There is little evidence to support or contradict the traditional methods of sizing an OPA. Current teaching suggests that the length of the OPA should correspond with the vertical distance between the patient's incisors and the angle of the jaw (Figure 1.10).[16] This measurement is achieved by placing the flange of the OPA against the

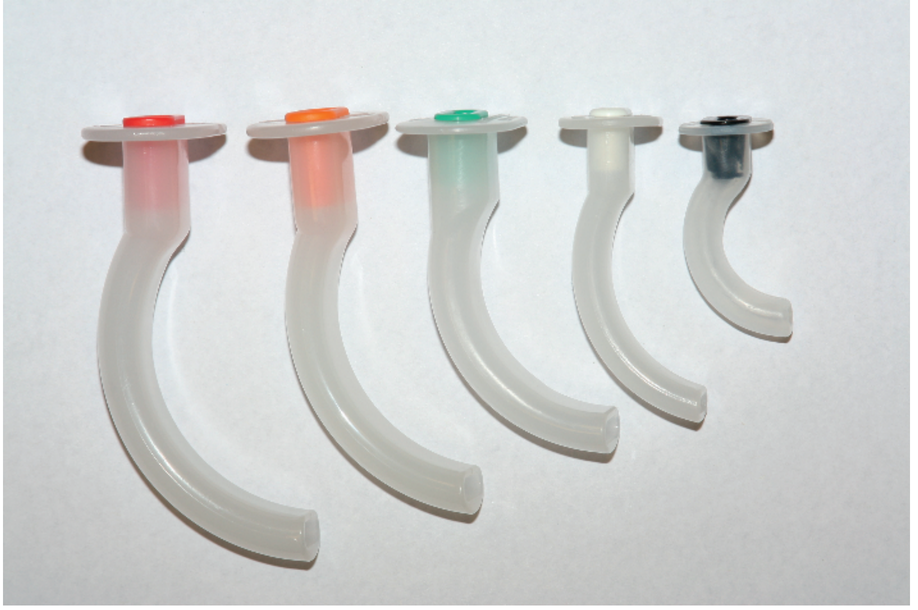

Figure 1.9 Oropharyngeal airways.

Figure 1.10 Measuring an OP airway.

patient's cheek, parallel to the front of the incisors and viewing the tip at the angle of the jaw.[18] If the airway is too long it may occlude the airway by locating within the vallecula and displacing the epiglottis; if too short it will not separate the soft palate or tongue from the posterior wall of the pharynx.

Contraindications

The OPA should not be used in any patient with an intact gag reflex.

Equipment required

Range of oropharyngeal airways.

Techniques for insertion

Procedure	Additional information/rationale
1. Select appropriate size.	If too short the airway would not separate the soft palate from the posterior wall of the pharynx; too long may displace the epiglottis.
2. Where no risk of cervical spine injury exists, hyperextend the head and neck. Grasp the patient's jaw and lift anteriorly.	Stretches the anterior neck structures to relieve obstruction of the soft palate and epiglottis.
3. Using other hand, hold the OPA at its proximal end and insert it into the patients mouth with the tip pointing towards the roof of the mouth.	Avoids unnecessary trauma to the delicate tissues in the mouth and inadvertent blocking of the airway by pushing the tongue back.
4. Once the tip reaches the level of the soft palate, gently rotate the airway 180° until it comes to rest over the tongue.	Brings the OPA into the alignment required for use.
5. The flattened, reinforced section of a correctly sized OPA should lie between the patient's teeth/dentures or gums. The lips should not be pulled over the flange of the OPA as this may cause damage to the labial frenulum.	Acts as a bite block.
6. Verify appropriate position by listening for clear breath sounds and looking for chest rise and fall.	Ensures correct placement.

See also Figures 1.11–1.14.

In small children the above technique should not be used due to the friable nature of the hard palate. Instead a tongue depressor should be employed and the OPA should be inserted 'right side up' with the tip pointing towards the tongue rather than the roof of the mouth.[19] This technique may also be utilised for adult patients where a tongue depressor is available.[18]

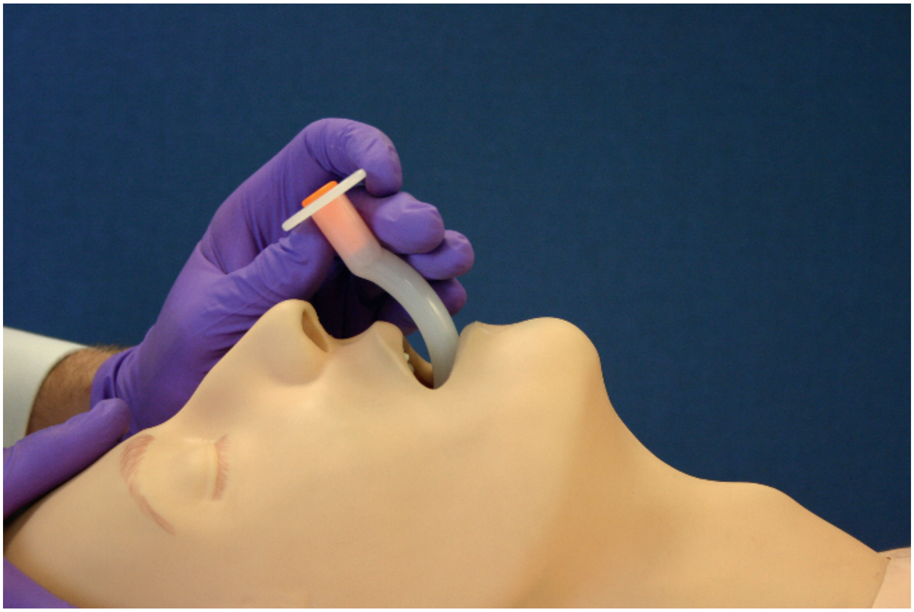

Figure 1.11 Insertion of an OPA.

Figure 1.12 Insertion of an OPA.

Figure 1.13 Insertion of an OPA.

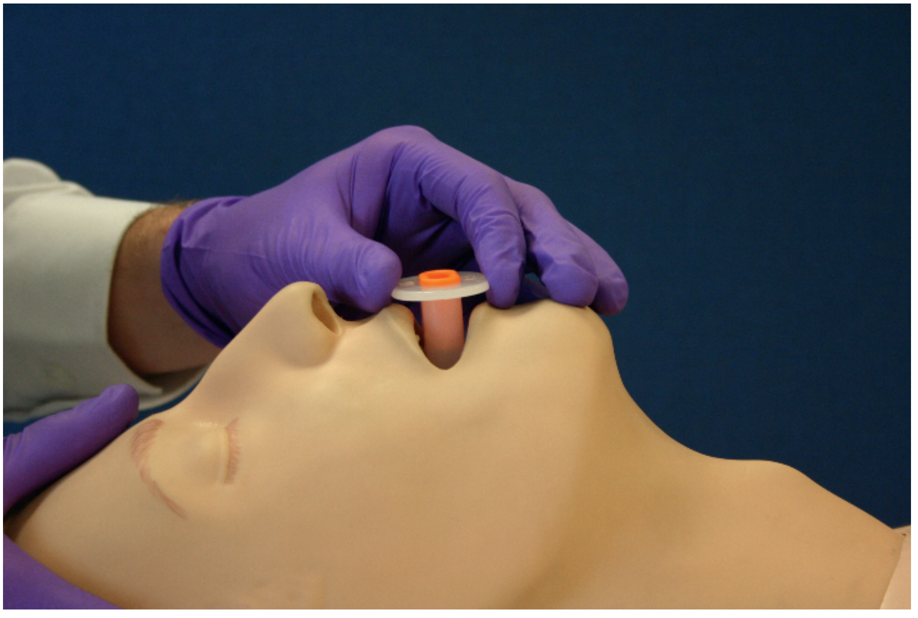

Figure 1.14 Insertion of an OPA.

THINK

What factors would influence you when deciding whether to use a nasopharyngeal or oropharyngeal airway?

Advanced airway adjuncts and cricothyroidotomy

Laryngeal mask airway

See Figure 1.15.

The laryngeal mask airway (LMA) comprises a wide-bore tube with an elliptical inflatable cuff designed to seal around the laryngeal inlet.[16] The proximal end of the tube is fitted with a standard 15/22 mm connector. The LMA can be placed blind, requires less skill and is easier to insert than a tracheal tube.[20-26] The LMA provides for more efficient ventilation than with a bag-valve-mask (BVM) alone,[27] and when an LMA can be inserted without delay, it is recommended that bag-mask ventilation be avoided altogether.[16]

Figure 1.15 Laryngeal mask airway.

The LMA has been studied during cardiopulmonary resuscitation (CPR) but no studies have made a direct comparison with endotracheal intubation. The literature suggests that during CPR successful ventilation is achieved with an LMA in 72–98% of cases[28-34] and there is a reduction in the number of cases of regurgitation.[35] The perceived disadvantages of the LMA over endotracheal intubation surround the increased risk of aspiration and the inability to provide adequate ventilation for those with low lung or chest compliance.[16] There is currently no evidence demonstrating whether it is possible to perform continuous chest compressions with an LMA in situ; this may be one of the main benefits of endotracheal intubation.

A case series suggests that the LMA may have a use in the prehospital management of critically ill patients with inaccessible airways following trauma,[36] a contention supported by a manikin-based study comparing LMA with endotracheal intubation or Combitube in a simulation of restricted access to the patient's airway.[37] Times to ventilation with the LMA were much more rapid than with either of the other options but further research is required before a categorical recommendation can be made. Given the current level of evidence it is reasonable to suggest that where basic airway adjuncts do not provide the level of airway support required and endotracheal intubation is constrained by poor access to the patient's airway, the LMA should be considered as an alternative.

There are significant concerns regarding the intubation success of paramedics (mainly from literature in the USA [see later in this chapter]) and the LMA may be a reasonable alternative where endotracheal intubation has failed, or electively as part of a stepwise approach to airway management.

Sizing of a laryngeal mask airway

Sizing of the LMA is based upon the weight of the patient and this information can normally be found on the sterile packet and the LMA device itself. Table 1.1 gives typical ranges, but these values may change depending upon the brand of LMA used.

Contraindications

The LMA cannot be used in a patient with an intact gag reflex.

As the LMA is less effective at preventing aspiration, consideration needs to be given to alternative methods in patients at higher risk of regurgitation; for example, patients who are pregnant or who have a hiatus hernia.[38]

Table 1.1 Typical values for LMA

Size	Age/weight range	Maximum cuff inflation (mL air)
1	Neonates up to 5 kg	4
1.5	Children 5–10 kg	7
2	Children 10–20 kg	10
2.5	Children 20–30 kg	14
3	Children 30–50 kg	20
4	Small/normal adults	30
5	Normal/large adults	40

Equipment required

- LMA – range of sizes
- 50 mL syringe
- Tie
- Lubrication
- Stethoscope.

Procedure

Note: this describes the 'classic' technique; modified techniques exist for specific situations and LMA devices.

Procedure	Additional information/rationale
Check and prepare all equipment:	
1. Check the cuff by inflating it with 50% more air than is required. • Completely deflate the cuff, conforming it so that no folds appear near the tip; this may be achieved by pressing the device, cuff down, on a flat surface. Use the inside of the sterile LMA packet to minimise the risk of contamination. • Lubricate the base of the device with a water-soluble lubricant.	Reduces the risk of inserting a device that will fail. To ensure that the cuff will inflate and seal correctly when in situ. Hygiene. Minimise trauma during insertion.
2. The patient should be preoxygenated prior to insertion and ventilation should be interrupted for no more than 30 seconds to achieve correct placement. Before inserting the LMA, the patient's neck is flexed and the head extended ('sniffing position') by pushing the head from behind with the non-dominant hand.[39]	Preoxygenation replaces the primarily nitrogenous mixture of ambient air, which constitutes the patient's functional residual capacity, with oxygen, so increases the interval before desaturation in a patient who is hypoventilating or apnoeic.
3. Place the index finger of the dominant hand in the notch between the tube and the cuff	
4. Open the patient's mouth and slide the convex side of the airway against the roof of the patient's mouth.	Guides the LMA and avoids pushing the tongue backwards with the risk of airway obstruction.
5. Use your finger to push against the hard palate and advance past the tongue; once past the tongue, the LMA should advance easily. It is usually necessary to remove the dominant hand from the tube in order to facilitate final positioning of the LMA into the hypopharynx. Maintain a hold of the LMA with the sub-dominant hand whilst the dominant hand is withdrawn and then ease the LMA into its final position with the dominant hand.	

Procedure	Additional information/rationale
6. Inflate the cuff with the appropriate amount of air and, if properly positioned, the LMA should move out of the airway slightly (1–2 cm).	Inflation of the cuff forms a seal around the laryngeal inlet.
7. Following inflation, ventilate the patient and look for rise and fall of the chest. Auscultate the chest to confirm air entry.	Re-oxygenates the patient and ensures correct placement.
8. Secure the tube with an appropriate tie and consider using a rigid cervical collar to reduce flexion and extension of the head and neck.	The LMA was not designed to be used in patients who are being transported so careful attention must be paid to the airway during any patient manoeuvres.

Complications

Complications from LMA use can be categorised into mechanical, traumatic and pathophysiological.[40] Mechanical complications relate to the technical performance as an airway device and include failed insertion (0.3–4%), ineffective seal (<5%), and malposition (20–35%).[40] Traumatic complications relate to local tissue damage and include sore throat (10% with ranges between 0–70%), dysphagia (4–24%), and dysarthria (4–47%).[40] Pathophysiological complications relate to the LMA's effects on the body and include coughing (<2%), vomiting (0.02–5%) detectable regurgitation (0–80%), and clinical regurgitation (0.1%).[40]

There is little evidence available from prehospital studies so the figures presented above are derived largely from studies in the operating department. It has been stated that prehospital LMA success rates are lower than those seen in the hospital cardiac arrest or elective surgical patient but the data are old and may not reflect current trends.[41]

An incident of gastric rupture associated with paramedic use of the LMA during CPR has been reported although there appears to be only one published report of such an occurrence;[42] healthcare professionals should not discount the use of the LMA on the basis of one case report.

Endotracheal intubation

Endotracheal intubation (ETI) is considered to be the 'gold standard' of airway management[43] and involves the introduction of a cuff-sealed tube into the trachea. The cuffed tube seals the trachea up to peak pressures of approximately 50 mbar and prevents aspiration of solid or liquid foreign material.[44] Endotracheal intubation confers numerous advantages over the bag-valve-mask:[44]

- Secure ventilation with patient-adjusted airway pressures
- Optimum protection against aspiration
- Option of administering medication (e.g. epinephrine, lidocaine, atropine, naloxone)
- Bronchial suction.

The indications for prehospital ETI may be dependent upon the availability of sedatives or neuromuscular-blocking agents to facilitate endotracheal intubation; without pharmacological adjuncts, the practitioner may be unable to intubate unless the patient has a severely reduced level of consciousness.

There are numerous concerns surrounding out-of-hospital intubation by paramedics as studies evaluating either survival or neurological outcome following out-of-hospital ETI have failed to show any significant benefits.[45-59] It is acknowledged that there are weaknesses in many of these studies in that they were mainly retrospective analyses of trauma patients involving a single centre or countrywide trauma register. Studies tended to evaluate survival to discharge only rather than long-term follow-up, and often inferred neurological outcome based on discharge destination, e.g. to home, to rehabilitation centre; none used formal neurological scales to measure outcomes. Not all studies took into account the confounding factors that may have affected patient outcome, which is a major factor in retrospective studies, and some did not adjust outcomes for severity of injury or illness.

Although there are inherent weaknesses in the studies, it has to be recognised that multiple studies have arrived at similar conclusions.

THINK

You have tried unsuccessfully to intubate a patient but still believe this to be the correct course of action. What can you do to improve your chances of success?

Equipment required

- Oxygen and ventilation equipment
- Laryngoscope handle and blades
- Endotracheal tube, bougie
- 10 mL syringe
- Water-soluble lubricant (see notes below)
- Magill forceps
- Tape, tie or commercial tube securing device
- Suction.

Preparation of equipment and discussion

- **Oxygen:** Ensure adequate supply of oxygen with which to ventilate the patient.

- **Endotracheal tube:** Select correct tube size. The size of the tube is printed on the sterile package as well as on the tube itself. Traditionally, the largest diameter was advocated to minimise resistance to airflow; 9 mm for an adult male, 8 mm for an adult female and 7 mm for an adolescent[60] (see Table 1.2 for paediatric sizes). Balance the desire for a large diameter with the risk of mucosal damage that may be caused by an oversized tube.[60]
  - Inflate the cuff with 10 mL of air and check there are no leaks.
  - Check to ensure that the connector is firmly attached to the proximal end of the tube.
  - There is debate as to whether tubes should be cut or uncut; cutting tubes to the appropriate length reduces the risk of right bronchial intubation and may reduce movement and rotation of the tube when connected to a ventilator.
- **Laryngoscope blades and handle:** It is best to have a selection of blades available as some patients may be easier to intubate with one rather than another. Check the integrity of the blade, and the brightness and tightness of the bulb. A straight[61] or McCoy blade[62] may improve the view at laryngoscopy; however, extra skill and training are required for these laryngoscopes to be effective. There is no evidence to suggest that it is appropriate to have either the straight or the McCoy blade available for paramedics.[63] A recent device, the Airtraq laryngoscope has proved successful in manikin trials,[64,65] and will be discussed later in this chapter.
- **Bougie:** Bougies are 60 cm long tracheal tube introducers with an external diameter of 5 mm to accommodate tracheal tubes >6 mm internal diameter. There is generally a 'coudé' tip, which comprises a 35 degree angle 2.5 cm from the distal end; this facilitates insertion of the bougie through the vocal cords when only the epiglottis (Grade III view) or tip of the arytenoids (Grade II view) can be visualised. The traditional technique has been for a 2nd operator to thread the tube over the bougie although there is sense in having the tube already positioned on the bougie in prehospital care given the emergency nature of the intubation.
  - A literature review recommended that the bougie should be available to paramedics as long ago as 2000[66] but it is likely that many paramedics do not have access to, or have not been trained in their use.[63] A shaped bougie has been shown to be better than a straight bougie,[67] and JRCALC are now advocating that a bougie be available for all prehospital intubation. Given that the practitioner should be aiming for a first time successful intubation, it is reasonable to assert that a bougie should be used for EVERY intubation rather than visualising first only to find a grade III view.
  - **Recommendation:** All ambulance paramedics should have access to and be trained in the use of bougies. Paramedics should routinely use a bougie for tracheal intubations to avoid delays created when a poor view is obtained through laryngoscopy.
- **Magill forceps:** Magill forceps are curved forceps that may be useful for removing obstructions under direct vision, or helping to guide the tip of the tube towards the trachea.
- **Lubricant:** Tubes for orotracheal intubation are usually lubricated prior to use as a matter of routine based on tradition. Searches have identified no literature to support the use of water-based lubricant to ease the passage of the tube and products such as KY Gel have been shown not to reduce the incidence of post-operative sore throat.[68] There has been a report of obstruction of a lubricated

tracheal tube with a flexible clear membrane said to be 'like a lump of glue'.[69] Analysis suggested that the most likely contaminant that caused the problem was a water-based lubricant.[70]

- It has been stated that lubricants may result in tube obstruction and interfere with inspection of the tube[70] and there appears to be nothing to be gained from lubricating oral tracheal tubes.[71]
- **Recommendation:** Routine lubrication of orotracheal tubes is to be discouraged until evidence shows that benefits outweigh the potential problems.

Table 1.2 Recommended tracheal tube sizes for children

Age	Diameter (mm)	Length (cm)
Birth	3	10
1 month	3	10
3 months	3.5	11
6 months	4	12
9 months	4	12
12 months	4.5	13
18 months	4.5	13
2 years	5	14
3 years	5	14
4 years	5	15
5 years	5.5	15
6 years	6	16
7 years	6	16
8 years	6.5	17
9 years	6.5	17
10 years	7	18
11 years	7	18

Reference: Joint Royal Colleges Ambulance Liaison Committee. *UK Ambulance Service Clinical Practice Guidelines*. London: JRCALC, 2006.

Confirming placement of the tube

There has been concern over the safety of endotracheal intubation by paramedics in the prehospital environment. At time of writing no studies have taken place in the UK to evaluate paramedic success rates although the College of Paramedics (CoP) Research and Audit Committee are looking to facilitate this study. Reports suggest that between 5.8% and 25% of endotracheal intubations carried out by paramedics are misplaced and unrecognised on arrival at the emergency department (ED).[72,73,74,75]

In a 2004 survey, 76% of UK ambulance services provided nothing more than a stethoscope to confirm tube placement.[63] A stethoscope on its own is unreliable to confirm correct placement as breath sounds have been shown to be present in 48% of oesophageal intubations.[76]

Additional measures for confirming tube placement

- **Oesophageal detector devices:** The oesophageal detector device (ODD) is a suction device fitted to an endotracheal tube (ETT) and depends on anatomical differences between the oesophagus and the trachea. When suction is applied with an oesophageal ETT placement, the oesophageal wall collapses and very little air can be suctioned. The person operating the device will notice a marked resistance. With correct ET tube placement, the rigidity of the tracheal cartilage prevents collapse so air can be suctioned and no resistance will be noticed.
  - Reports on the effectiveness of the ODD have varied. One report found that only 50% of oesophageal intubations were detected,[77] whilst two other studies found the ODD to have high sensitivity for oesophageal intubation but low specificity for tracheal intubation (meaning correctly placed tubes may have been removed)[78,79] A further study found the ODD to be more specific for tracheal intubation than end tidal CO_2 in the context of cardiac arrest although this study was undertaken in the ED rather than out of hospital.[80]
  - **Recommendation:** The ODD is useful as a further adjunct to confirm tube placement but it is neither sensitive enough nor specific enough to be used as the sole measure of correct placement.
- **Capnometry:** Capnometry measures the amount of CO_2 in a gas sample. Capnometers may use colorimetric or electronic technology. Colorimetric capnometers use a chemical reaction to detect the presence of CO_2 in exhaled gas. A filter containing metacresol purple is placed between the ETT and ventilation device and when CO_2 is greater than 2%, the filter turns yellow. This reaction is rapid and should occur with each breath.[38] Electronic capnometers detect and calculate the amount of CO_2 in each breath and provide real-time indication of the patient's CO_2 levels. It should be noted that capnometry is one of the minimum standards used by UK anaesthetists[81] and its use should be compulsory in pre-hospital care.
- **Condensation in the tube:** Teaching related to condensation in the tube is based on tradition rather than evidence. Only one study has been conducted to evaluate the value of misting in the tube and that was conducted on dogs so has limited applicability to humans. In this study, condensation appeared in 100% of tracheal intubations and 83% of oesophageal intubations.[82]
  - **Recommendation:** Evidence is limited but condensation in the tubing should not be relied upon as an indicator of tracheal tube placement.

Key Point

No single method of assessing tube placement is infallible so practitioners should use more than one methodology. Combined use of visualisation, ODD, capnography, auscultation, and patient condition should conspire to improve the recognition rate for misplaced intubations.

How many attempts?

- A large multi-centre prospective study looked at the number of attempts required by paramedics, out-of-hospital nurses and physicians to accomplish out-of-hospital ETI.[83] Cumulative success for the first three attempts was 69.9%, 84.9% and 89.9% respectively with an overall success rate of 91.8%. When considering the number of attempts, the practitioner needs to assess the time taken to undertake ETI. Rapid sequence induction has been shown to add 10.7 minutes to on scene times whilst standard ETI added a mean of 5.2 minutes.[84]
  - **Recommendation:** It would be reasonable to suggest a maximum of three attempts at ETI as the overall success rate does not increase with subsequent attempts but the increased time to secure an airway, the delay on scene and the emergency nature of the intubation suggest that fewer attempts should be made. Where an intubation fails, consider if another member of the team is better placed to successfully perform the task. It may be better to limit the number of intubation attempts on any patient to a maximum of two to minimise the risks to the patient.

Airway positioning and manipulation

- **Head position:** The 'sniffing' position has been widely accepted as the correct position for alignment of the airway.[85,86] In cases of Cormack and Lehane grade III view under direct laryngoscopy, elevation of the patient's head beyond the sniffing position and external laryngeal pressure may improve the view.[87] The utility of the 'sniffing' position for intubation outside the hospital environment has not been established.[88]
- **Cricoid pressure v Bimanual laryngoscopy v BURP:** Initially described by Sellick in 1961,[89] cricoid pressure is used during laryngoscopy to prevent regurgitation of stomach contents into the lungs by compressing the oesophagus. The value of this manoeuvre has been questioned in a study that found that the oesophagus was lateral to the larynx in >50% of study subjects and that cricoid pressure caused a small amount of airway compression in 81% of the subjects studied.[90] Cadaver studies have demonstrated the efficacy of cricoid pressure [91] and clinical studies showing that gastric insufflation with air during mask ventilation is reduced when cricoid pressure is applied.[92]

Studies have demonstrated that the quality of laryngeal view is likely to be worsened by cricoid pressure.[93,94]

Bimanual laryngoscopy – the manipulation of the larynx by the free hand of the intubationist – has been shown to improve the laryngeal view compared with cricoid pressure and backwards, upwards, right pressure (BURP) on the thyroid cartilage, or no manipulation.[95]

- **Recommendations:** The sniffing position is important in prehospital intubation but where a grade III view exists, the practitioner should consider asking an assistant to elevate the head beyond the sniffing position and applying external laryngeal pressure. Cricoid pressure should not be used to improve the view during laryngoscopy but may be useful when ventilating with a bag-valve-mask. Bimanual laryngoscopy should be taught and practitioners should use this technique in preference to cricoid pressure or BURP of the thyroid cartilage.

Preoxygenation

Preoxygenation replaces the primarily nitrogenous mixture of ambient air, which constitutes the patient's functional residual capacity, with oxygen, so increasing the interval before desaturation in a patient who is hypoventilating or apnoeic. The effectiveness of preoxygenation has been found to be limited in those with significant cardiopulmonary pathology such as congestive heart failure and respiratory failure complicated by excessive secretions,[96] and it is likely that patients who will be intubated in the prehospital environment will be physiologically compromised. Preoxygenation may be difficult to achieve but effort should be expended to ensure that the patient is well oxygenated before intubation attempts take place. There is no categorical evidence as to how much preoxygenation is required but it is likely to be more than the 4–8 vital capacity breaths used in elective preoxygenation.[97] It is suggested that SpO_2 levels should be 100% for two minutes prior to intubation and should not be allowed to fall below 96%[38] although SpO_2 readings will not be available in a cardiac arrest situation.

Procedure

Procedure	Additional information/rationale
1. Check, prepare and assemble equipment.	
• Ask colleague to preoxygenate patient whilst equipment is being prepared	Increases interval before desaturation during intubation attempt
• Remove the patient's upper and lower dentures, if present, immediately before laryngoscopy.	Provides greater aperture for inserting laryngoscope and tubes.
• Position patient in the 'sniffing' position.	Aligns the axes of the airway
2. Holding the laryngoscope in the left hand, insert blade in right hand side of mouth and displace tongue to the left. Move the blade towards the midline and advance until the distal end is located in the vallecula; lift the laryngoscope handle slightly upward and towards the feet without levering back on the teeth or gums. At this point check the position of the blade – it may need to be adjusted to visualise the cords.	A curved blade should be placed in the vallecula, a straight blade is normally used to lift the epiglottis directly.
3. Visualise the larynx and insert the ETT under direct vision. Consider use of bimanual laryngoscopy and/or repositioning of the patient's head if the view is sub-optimal.	
4. Use a bougie to aid tracheal placement.	
5. The black mark on the distal end of the tube should pass just beyond the vocal cords.	Reduces the risk of intubation of the right main bronchus and prevents inflation of the cuff between the vocal cords.

Procedure	Additional information/rationale
6. Inflate the cuff with just enough air to stop the leaking sound around the tube. In a correctly sized tube this should require only 4–6 mL[38]. Ventilate the patient using BVV or mechanical ventilator.	Forms a seal to prevent aspiration.
7. Check tube placement by listening across the stomach and then across the lungs for bilateral breath sounds. Use ODD, and capnometry as per local guidelines. When in doubt, remove the tube and re-ventilate.	Ensures correct placement of endotracheal tube.
8. Insert OP airway.	Acts as a bite block.
9. Secure tube with commercially produced device, tape or bandage.	Helps to maintain correct tube positioning during patient movement.
10. Consider applying cervical collar.	Minimises tube movement during transportation of the patient.
11. Recheck tube placement periodically, especially after patient movement.	Ensure that the tube is still correctly located.

Airtraq®

The Airtraq is an anatomically shaped laryngoscope with two separate channels: An enclosed channel that contains a high definition optical system, and a guiding channel that holds the endotracheal tube (ETT) and guides it through the vocal cords. It is a single-use device that can be used with any standard endotracheal tube. Recent studies have shown that the device improves the view, reduces time for tracheal tube placement, and appears to be easier for less experienced intubationists to acquire the skills of intubation.[98-100] At time of writing the device is not available for use by UK paramedics, but it is felt that this is such an important breakthrough that its inclusion is warranted.

Procedure

Procedure	Additional information/rationale
Preparation	
1. Check, prepare and assemble equipment.	
2. Ask colleague to preoxygenate patient whilst equipment is being prepared.	Increases interval before desaturation during intubation attempt.
3. Remove the patient's upper and lower dentures, if present, immediately before laryngoscopy.	Provides greater aperture for inserting Airtraq and tubes.

Procedure	Additional information/rationale
4. Use of the 'sniffing the morning air' position is less important with the Airtraq but the patient's head should not be hyperextended on the neck.	
5. Select the ETT size and the corresponding Airtraq.	
6. Turn the light ON. Wait until the light stops blinking if the patient is breathing spontaneously.	When the light stops blinking, the lens is heated to prevent misting. This is only necessary in a breathing patient.
7. Lubricate the ETT and place it into the Airtraq's guiding channel.	Facilitates easy passage of tube through Airtraq device.
Airtraq placement	
1. Insert the Airtraq into the midline of the patient's mouth.	
2. Slide the Airtraq through the oropharynx and larynx, keeping it in the midline.	
3. Look through the eyepiece to view the airway and to identify structures.	
4. Place the tip of the Airtraq at the vallecula. Gently lift up the Airtraq to expose the vocal cords.	
5. Alternatively the tip can be placed under the epiglottis (Miller style).	
ETT insertion	
1. Align the centre of the visual field by gently moving the tip of the Airtraq.	
2. Advance the ETT by gently pushing it down the guiding channel until you see the ETT passing through the vocal cords.	
3. If the ETT won't advance, slowly repeat the BACK & UP manoeuvre until vocal cords are centred in the view field: BACK: Rotate the Airtraq back, taking it away from the glottis. UP: Gently pull the Airtraq Up.	Should help to align the tip of the ETT with the opening of the glottis.

Procedure	Additional information/rationale
Verification, Airtraq removal and disposal	
1. Verify ETT placement and insertion length as previously described. Inflate the ETT cuff, connect the ETT to the breathing circuit and verify placement and seal.	
2. Separate the ETT from the Airtraq by pulling it laterally and then rotate the Airtraq backwards. Make sure to hold the ETT.	
3. Insert OP airway.	Acts as a bite block.
4. Secure tube with commercially produced device, tape or bandage.	Helps to maintain correct tube positioning during patient movement.
5. Consider applying cervical collar.	Minimises tube movement during transportation of the patient.
6. Recheck tube placement periodically, especially after patient movement.	Ensure that the tube is still correctly located.

Needle cricothyroidotomy

Needle cricothyroidotomy is a technique used as a temporary life-saving procedure when it is determined that the airway and ventilation cannot be maintained in any other way[101]. It represents the final step in the Difficult Airway Society's guidelines for managing the 'can't intubate, can't ventilate' emergency.[102] Needle cricothyroidotomy involves the insertion of a 14/16 gauge cannula into the trachea via the cricothyroid membrane with ventilation achieved via a low-pressure oxygen set-up or, less commonly, jet ventilator. Needle cricothyroidotomy is inferior to the surgical procedure due to the limited airflow afforded by the narrow lumen but has been shown to be the technique of choice in the prehospital and emergency department.[103-108] The use of a low-pressure oxygen delivery system is ineffective and all ambulance services should be provided with high-pressure jet ventilation systems.[101] Needle cricothyroidotomy should be considered as an emergency procedure to be used for no longer than 15–45 minutes until a more definitive airway can be secured.[109]

Indications for use

Can't intubate; can't ventilate emergencies.

Complications

- The technique provides high flow of oxygen to the lungs but does not allow for proper ventilation. CO_2 levels will rise quickly so transportation should be expedited rapidly in order to secure a definitive airway.

- Bleeding may occur at the wound site although this is rare.
- Subcutaneous emphysema through incorrect catheter placement and excessive air leakage around the insertion site.
- Risk of barotrauma or pneumothorax when using jet ventilation – this can be minimised by opening the release valve only long enough to ensure adequate rise of the chest.

Equipment required

- 14/16 gauge catheter-over-needle cannula with 10 mL syringe attached
- Alcohol swab
- Oxygen tubing with 3-way tap
- Oxygen cylinder and flow-meter
- Tape.

Procedure

Procedure	Additional information/rationale
1. Check, prepare and assemble equipment.	Remove the blood reservoir from the rear of the cannula and attach the 10 mL syringe.
2. Maintain attempts at oxygenating the patient and clearing obstruction whilst preparing equipment.	May prevent the need for the procedure if the airway can be cleared by other means.
3. Identify the cricothyroid membrane in the midline between the thyroid cartilage and cricoid cartilage.	Locates the correct point of insertion.
4. Swab the site and then insert tip of cannula through the membrane angled at 45° towards the feet; aspirate on the syringe as the needle is inserted.	Tracheal entry can be confirmed when air freely enters the syringe.
5. Railroad the cannula over the needle into the trachea and secure with tape.	
6. Connect one end of oxygen tubing to the catheter and the other end to the jet ventilator.	This can be achieved by connecting the oxygen supply via a Y-connector – give 15 L/min for an adult.
7. Open the release valve on the jet ventilator and adjust the pressure to provide adequate chest rise.	
8. Auscultate over both apices and lung bases, and over the epigastrium.	To confirm placement.

Chapter Key Points

1. Airway management is a key feature of prehospital care.
2. It is essential to understand the anatomy of the airway in order to perform airway management knowledgably.
3. Airway management techniques should be used in a step-wise approach.
4. The practitioner needs to be able to justify airway management decisions.
5. Each airway technique has its own inherent problems; the practitioner should be aware of the problems and limitations associated with each technique and have tools to remedy them.

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