# Tracheal intubation

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## Abstract

Tracheal intubation is the act of placing a tube into the trachea. The tube enables oxygen delivery and removal of carbon dioxide, while also allowing for the administration of pharmacological agents. Intubation is the most reliable method of maintaining an airway under anaesthesia, and for protection against aspiration of stomach contents. Traditionally, intubation is achieved by direct visualization of the glottis, but now indirect laryngoscopy (via a videolaryngoscope) is a common alternative. Prior to embarking upon intubation, a thorough patient history and examination must be undertaken by the laryngoscopist; equipment must be prepared and checked; a trained assistant present; and an experienced anaesthetist available in case assistance is required. Once the endotracheal tube has been placed, correct positioning must be confirmed via both clinical examination and monitoring, including capnography. Tracheal intubation is a procedure that should only be undertaken by trained operators and is not without risk. It is important to note that it is failure to oxygenate patients rather than failure to intubate that ultimately leads to serious morbidity and mortality. The Difficult Airway Society has produced guidelines on how to manage unanticipated difficulty in tracheal intubation; it is essential that every practitioner trained to intubate patients is familiar with these algorithms and the key principles of safe airway management.

**Keywords** Airway; anaesthesia; capnography; endotracheal; extubation; intubation; laryngoscopy; oxygenation

**Royal College of Anaesthetists CPD Matrix:** 1B02, 1C01, 1C02, 3A01

## Learning objectives

After reading this article, you should be able to:

- describe the different indications for intubation
- demonstrate appropriate patient positioning before undertaking airway management
- explain the principles of how to intubate
- summarize the Difficult Airway Society Unanticipated Difficult Intubation guidelines

## Introduction

Tracheal intubation is the act of passing a tube into the trachea via the mouth or nose (although access to the trachea can also be created via a direct surgical approach, namely a tracheostomy). In adults, the *endotracheal* tube typically has an external cuff at its distal end, which must be positioned below the vocal cords. Once inflated, this provides a seal in the trachea, optimizing assisted ventilation and ensuring that soiling of the lungs cannot take place. This is a feature unique to tracheal tubes; other commonly used airway devices, such as supraglottic airways, do not offer the same level of protection.

Tracheal intubation is commonly used as part of general anaesthesia and during resuscitation. The purpose of tracheal intubation is primarily for airway maintenance and the facilitation of assisted ventilation gas exchange. It also protects the airway against contamination, such as from gastric contents. Pharmacological agents can also be administered via the endotracheal tube, most commonly sedative anaesthetic agents (volatiles) but also bronchodilators.

### Indications for tracheal intubation

**Patient factors:**

- Prevent tracheal soiling under GA
  - Gastro-oesophageal reflux disease or hiatus hernia
  - Inadequate fasting time
  - Pregnancy
- Respiratory concerns
  - Anticipated 'difficult' airway, e.g. malignancy
  - Lung disease or injury
  - Morbid obesity
  - Resuscitative
- Cardiac arrest
  - 'High risk' airway, e.g. facial burns
  - GCS <9
  - Intensive care

**Surgical factors:**

- Abdominal surgery when paralysis essential
- Head and neck surgery, including shared airway procedures, to optimize surgical access
- Neurosurgery to provide a secure airway in the prone position
- Prolonged surgery

### Relative contraindications

- High risk of failure, such as obstructing upper airway pathology or foreign body
- Lack of user experience with the technique

## Preoperative assessment

A thorough history and examination should be performed to try to elicit any potential airway difficulties before anaesthetizing the patient for intubation. Reviewing previous anaesthetic charts is often an invaluable source of information. When pre-assessing

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### Clinical features that predict a difficult airway

Airway assessment:

- Hoarse, stridulous voice
- Mouth opening ≤3 fingers (inter-incisor distance <4.6 cm)
- Marked overbite of the teeth or loose incisors
- Poor visualization of the palate (Mallampati score 3 or 4)
- Thyromental distance (Patil's test) < 6.5cm
- Poor atlanto-axial extension and mobility (Delilkan test)
- Poor mandibular protrusion (anterior mobility)

Additional factors predicting difficult mask ventilatio

- Increased neck circumference
- Presence of a beard
- Edentulous patient

**Box 1**

patients it is important to consider not only the risk factors for a difficult intubation, but also the other two facets that would constitute a *difficult airway*, namely the ease, or otherwise, of both facemask ventilation and supraglottic airway insertion. **Failed intubation is a serious event, but failed ventilation is a life-threatening one**

There are many clinical scenarios that increase the risk of a difficult airway. These include chronic medical conditions such as rheumatoid arthritis, ankylosing spondylitis, syndromes such as Pierre-Robin, and patients who have undergone radiotherapy as part of head and neck cancer treatment. More acute scenarios such as cervical spine trauma or infective or malignant upper airway pathology will also present significant difficulty and require proactive management and strategy planning.

Unfortunately, even with a thorough preassessment, difficult intubation is often not anticipated. Analysis of the Danish Anaesthesia Database in 2014 showed that 93% of difficult intubations were unanticipated.[1] However, bedside airway assessment is recommended, despite the poor positive predictive value. There are multiple tests available but none are sensitive nor specific enough to be used in isolation. Most anaesthetists employ a combination of some, but not all, of these tests. Box 1 lists some features that would suggest potential difficulty with intubation and/or face mask ventilation.

**Figure 1** Macintosh (curved) and Miller (straight) blade laryngoscopes.

## Equipment

The Miller and Macintosh laryngoscopes (Figure 1) have been in widespread use since the 1940s. While there have been small modifications to the designs over the years, these devices have been the mainstay of clinical practice since their introduction over 70 years ago, and Macintosh direct laryngoscopy (DL) remains the most commonly employed intubation device worldwide. Over the past decade, however, videolaryngoscopy (VL) has gained in popularity. VLs provide a high-quality, enlarged, *indirect* image (on a monitor) of the upper airway structures. The advantages of VL include: the VL view of the glottis is superior to that of DL, which facilitates successful intubation; it is easier for trainers to see exactly what the learner is visualizing; and airway assistants can better aid the laryngoscopist as they can visualize the intubation process. However, the superior glottic view with VL is not always associated with easier passage of the endotracheal tube and requires appropriate training and skill maintenance. The additional equipment required for tracheal intubation is shown in Box 2.

## Procedure

### Positioning

The patient should lie supine or slightly head up on a trolley that can be rapidly put into the Trendelenburg (head down) position. This is to ensure that, should there be regurgitation of stomach contents, material will collect in the oropharynx where it can be suctioned, rather than transiting to the lungs which may cause a pneumonitis. The height of the trolley also needs to be adjustable.

For patients with a normal body mass index, the optimal position for airway management is the 'sniffing the morning air' position. This is a combination of lower cervical spine flexion (usually provided by a pillow) with head extension at the atlanto-occipital joint. This should ideally provide a direct line of sight between the pharyngeal and laryngeal airway axes (Figure 2).

There are specific scenarios where positioning should be adapted. For example, patients with cervical spine pathology may not tolerate this position and may be better served by accepting a sub-optimal head and neck position and using an indirect laryngoscopic approach which does not depend upon on the direct line of sight described above. For morbidly obese patients, simply putting them into the sniffing the morning air position may be insufficient for airway optimization and specialist equipment such as a head elevation pillow to *ramp* the patient will assist airway management (the tragus should be horizontally in line with the sternal notch). If ramping is not undertaken, the laryngeal and pharyngeal axes will not line up and both mask ventilation and intubation will potentially be difficult or impossible.

### Preoxygenation

This term describes the administration of oxygen to a patient prior to the induction of anaesthesia to increase the time period before desaturation will occur (the 'safe apnoea time'), something that may occur during intubation particularly when difficulty is encountered. The aim of preoxygenation is to denitrogenate the lungs, replacing nitrogen with oxygen. It is

## Equipment for intubation

*Bougie*
A malleable rod used to facilitate passage of the tube when difficulty is encountered
*Breathing system*
An inflating bag and oxygen supply to ventilate post-intubation
*Capnography*
Monitoring of end-tidal carbon dioxide. Usually displayed as a waveform. Aids confirmation of airway device placement
*Checklist*
An intubation checklist, such as the DAS Critically Ill Intubation Guidelines,[2] to be completed with entire team present
*Cuff manometer*
Used to measure the pressure in the tracheal tube cuff after inflation
*Direct laryngoscope*
Laryngoscope handle, batteries, blade (most commonly a Macintosh (curved) size 3 or 4)
*Emergency oxygenation equipment*
Laryngeal mask airways, surgical cricothyroidotomy kit
*Endotracheal tubes (ETT)*
Usually 7.0 mm (internal diameter) for a small female up to 9.0 for a large male
Usually cuffed for adults, but many specialized tubes and sizes exist
*Facemask*
To provide effective ventilation before and during attempts at intubation
*Lubrication*
Water-soluble gel such as Aquagel to lubricate the ETT
*Magill forceps*
May be used to help guide an ETT between the vocal cords, particularly in a nasal intubation
*Patient monitoring*
Includes blood pressure, ECG, pulse oximetry and capnography
*Personal protective equipment*
Gloves, consider visor if infection risk
*Stethoscope*
To check placement of the ETT following intubation
*Stylet*
Stiffening rod that can be loaded inside the ETT to facilitate tube passage
*Suction*
With a Yankauer attached to clear any debris from the airway
*Syringe*
10 ml syringe for inflating the ETT cuff
*Tie*
Either a cotton tie, adhesive tape, or tube holding device to secure the ETT
*Videolaryngoscope*
Device, monitor, power source, optional disposable blade cover

**Box 2**

wise to undertake preoxygenation in all patients, as difficult intubation may be encountered unexpectedly.

Most commonly, preoxygenation is administered via a cushioned facemask. The patient is asked to breathe a high concentration of oxygen (approximately 95%) until their exhaled oxygen concentration exceeds 85%. The expiratory valve on the breathing circuit can also be utilized to deliver a small amount of positive end-expiratory pressure (PEEP) to help reduce atelectasis.

The concept of peri- rather than pre-oxygenation has gained popularity. This involves supplemental oxygen delivery throughout airway management and prolongs the safe apnoea time. This can be delivered simply using nasal prongs and low flows (2–3 L/min awake, rising to 15 L/min when anaesthetized), and can be used as an adjunct to face mask ventilation until the airway has been secured. Alternatively, high flow nasal oxygenation (HFNO) can deliver warm, humidified gas nasally at flows up to 50–70 L/minute and is a very effective gas exchange system prior to intubation, as long as the airway is actively kept patent (and, ideally, the mouth closed). The HFNO cannulae are slightly bulky and best used without a facemask. This can be particularly useful in patients who are likely to desaturate quickly, such as the obese or hypoxic patient, and for those with a potential difficult airway, where the intubation process may be prolonged. In both low and high flow systems, oxygenation will continue during airway management, but the latter is considerably more effective.

### Intubation

Barring emergency intubation, performed as part of resuscitation, intubation usually follows the induction of anaesthesia. The patient will be rendered unconscious by an induction agent, most commonly propofol, ketamine or thiopentone. Following this, a neuromuscular blocking agent will commonly be delivered. This

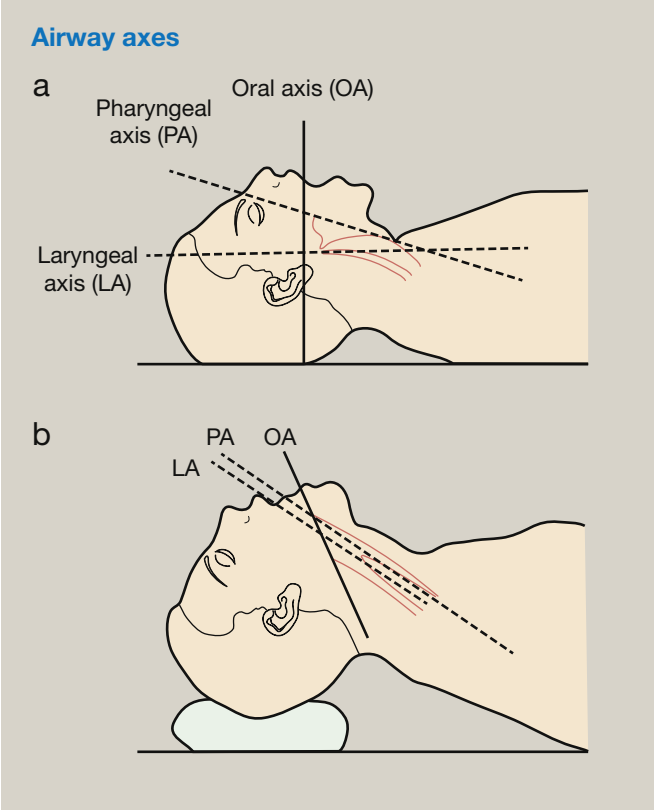


**Figure 2**

will facilitate intubation by paralysing the laryngeal muscles. It is important to remember that without neuromuscular blockade, bag mask ventilation may be more difficult due to residual pharyngeal tone interfering with airway patency.

To perform direct laryngoscopy, the patient's head needs to be extended on the neck, usually with the right hand, freeing the left to both hold the laryngoscope and open the mouth using the left little finger. The laryngoscope should be held close to the join between the blade and the handle, providing optimal manoeuvrability of the device while limiting the risk of dental damage. The blade is passed into the right side of the mouth delicately and carefully and the tongue swept to the left as the blade is moved to the midline. The first task is to attempt to visualize the epiglottis by lifting the tongue anteriorly using the blade.

The blade then needs to be advanced into the vallecula, which is anterior to the epiglottis. Once in this position, the handle is pulled in a forward and upright direction; again a lifting manoeuvre rather than levering one. This will facilitate the laryngeal and pharyngeal airway axes coming into alignment and minimize the risk of damage to the teeth. If the glottis is seen, then the endotracheal tube can be passed through the vocal cords into the trachea. Endotracheal tubes are marked with two distal black lines and these lines should be placed so one is either side of the vocal cords. Care must be taken to recognize the depth that the tube has been inserted by viewing the tube markings at the level of the lips.

If there is a poor or inadequate view of the laryngeal inlet, the operator or their airway assistant should attempt to optimize glottic view by performing external laryngeal manipulation before attempting intubation. Often this is best achieved by applying backwards and rightwards force (BURP) to the thyroid cartilage which lies in front of the larynx in the neck. In addition, intubation aids, such as a tube-stiffening stylet or an intubating bougie may facilitate passage of the tube through an anterior-placed glottis.

Once the endotracheal tube has been positioned appropriately through the vocal cords, the tube cuff, which sits immediately below the vocal cords, needs to be inflated with a small volume of air to a pressure of 20–30 $cmH_2O$. If the cuff is underinflated ventilation may be inadequate and the lungs will not be protected from soiling, while over-inflation can compromise blood flow to the tracheal mucosa. Simultaneously, the tube is connected to a breathing circuit with capnography attached and the lungs are manually ventilated.

Confirmation of tube position is elicited through a combination of clinical examination and use of patient monitoring. The tube should mist upon expiration, the chest should move equally, and breath sounds should be heard equally bilaterally. Patient monitoring should display a continuous capnography trace and adequate oxygenation is reflected in the patient's oxygen saturations. Missed oesophageal intubation is a well-documented cause of mortality and an important maxim to remember regarding the correct placement of endotracheal tubes is 'if in doubt, take it out'.

One must be aware of the 'No Trace = Wrong Place' video campaign launched by the Royal College of Anaesthetists (RCoA) and the Difficult Airway Society (DAS).[3] This states that following successful tracheal intubation, a capnography trace will be seen, *even in cardiac arrest.*

Following confirmation that the endotracheal tube is in the correct position, it should be secured with a cotton tie around the neck, adhesive tape or a tube-holding device. It is important to be mindful that the tube is secured at the same distance at the lips as was noted at intubation. Should the tube be inadvertently pushed in further, endobronchial intubation may occur and if it is withdrawn, the cuff may be displaced above the vocal cords.

The view obtained at direct laryngoscopy is graded by a Cormack and Lehane score which depends on the structures seen. Grade 1 equates to a full view of the glottis, grade 2 to a partial view, grade 3 to only seeing the epiglottis and grade 4 to a failure to visualize any of the periglottic anatomy. Grade 1 and 2 views usually translate to straightforward intubation. Grade 3 is likely to be difficult and grade 4 may be impossible without employing advanced, highly skilled, specialized techniques.

### Intubation using videolaryngoscopy

Unlike a direct laryngoscope, which has a consistent design based on the original Macintosh blade first described in the 1940s and used throughout the world, indirect laryngoscopes involving a projected image (a 'video') and differ from manufacturer to manufacturer. Some resemble a traditional Macintosh laryngoscope blade and can provide both direct and indirect views of the larynx, others are *hyper-angulated* providing only an indirect view. Some are *guided* devices with a channel for directing the ETT through the glottis, others are *non-guided* and require shaping using a preloaded stylet inside the tube to allow it to be directed along the hyper-angulated blade. It is critical that the operator is familiar with the device provided in their institution.

However, there are some general principles which apply to all VLs. The position of the head and neck is usually less critical compared to that with a conventional laryngoscope. If a good view of the larynx is obtained with a DL, then typically it is relatively easy to pass the tube through the cords. For VLs, particularly with hyper-angulated devices, a good view may be obtained but tube passage may remain difficult.

Once the ETT has been placed appropriately in the trachea, the same steps of cuff inflation and tube placement confirmation need to be undertaken as above.

### Safety considerations

**Planning:** Before considering intubating a patient it is essential to plan and prepare adequately for all eventualities, including an unforeseen difficult airway. This is best done as a team so that everyone involved is clear of the agreed strategy for airway management.

It is failure to oxygenate the lungs that ultimately causes harm, not failure to intubate. It is therefore critical that the primary focus is maintaining oxygenation and limiting attempts at intubation, which can contribute to airway deterioration as a result of repeated minor trauma. It is of vital importance that the

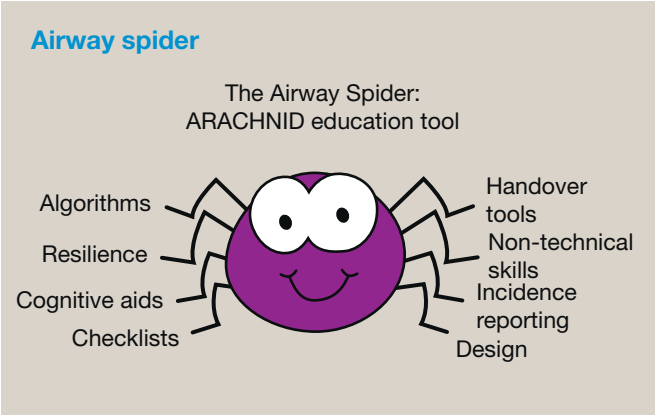


**Figure 3**

operator knows all aspects on how to manage a challenging airway and appreciates the benefit of calling for senior help early.

**Throat packs** can be used to reduced leaks if an uncuffed tube is used, or to soak up excess blood and secretions from oral or nasal procedures. There have been incidents where the throat pack has been left in situ post extubation, causing airway obstruction. To address this issue, throat packs should only be inserted when necessary. They should be added to the surgical swab count and their removal confirmed by direct visual inspection of the airway by the anaesthetist and documented as part of the theatre sign-in and sign-out.

**Extubation:** Airway management difficulties may not only be encountered at intubation, but also on extubation. It is critical that the operator is familiar with the DAS Extubation Guidelines.[4] General principles of safe management include ensuring the patient is preoxygenated prior to extubation, using a bite block, performing appropriate pharyngeal toilet, ensuring neuromuscular blockade is completely reversed and only removing the tube once the patient is awake with a regular respiratory pattern.

## Human factors in airway management

Successful airway management involves more than simply good technical skills. It was clearly demonstrated by the Fourth National Audit Project that human factors had an impact in up to 40% of the major airway complications reported.[5] There has been increasing emphasis within anaesthetic training to address this deficiency and one such educational tool that summarizes the key aspects is the acronym **ARACHNID**[6] (Figure 3):

- **A**lgorithms
- **R**esilience (ability to recover from untoward events)
- Cognitive **A**ids (such as models for dealing with emergency airway management)
- **C**hecklists
- **H**andover tools
- **N**on-technical skills (communication, team work, flattened hierarchy)
- **I**ncident investigation
- **D**esign (layout of theatres, equipment, working practices)

Simulation is an effective way of not only ensuring familiarity with algorithms, but also developing non-technical skills essential for managing airways successfully.

## Difficult Airway Society (DAS) guidelines

DAS updated their guidelines for the management of an unanticipated difficult intubation in 2015.[7] It is vital that every UK practitioner who manages airways, and particularly those that provide tracheal intubation, is familiar with the algorithm along with the difficult airway equipment available in their department. The algorithm is a four-step strategy, split into four plans, A to D.

- **Plan A** is for laryngoscopy to proceed to successful tracheal intubation, with a maximum of three attempts (four if an expert user also attempts intubation). Prior to each attempt, aspects of the operator's technique should be modified rather than simply repeating a failing technique. Help must be sought if difficulty arises.
- The focus of **Plan B** is no longer about intubating the patient but maintaining oxygenation. The recommendation is to insert a supraglottic airway device (SAD). If this is successful, there are then four options and there should be a deliberate pause for discussion of these options. Most commonly, waking the patient is the safest strategy but alternatives include intubating the trachea using the SAD as a conduit, proceeding without intubation with the SAD in situ or undertaking front-of-neck-access (FONA) via a tracheostomy or cricothyroidotomy.
- Should Plan B fail, then **Plan C** needs to be employed immediately with facemask ventilation and, if successful, patient wake-up.
- **Plan D** is the final stage of the algorithm. This is utilized for a patient who has not been successfully intubated, nor have they had successful ventilation via an LMA or a facemask. They now need a surgical cricothyroidotomy. It is vital that every practitioner undertaking tracheal intubation knows how to perform a surgical airway and to demonstrate this technique. DAS have produced a video which accompanies the electronic version of this article.[8] ◆

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