Anaesthesia for airway surgery

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Key points

Airway surgery requires a high degree of cooperation between anaesthetist and surgeon.

The choice of anaesthetic technique is dictated by the experience of the anaesthetist.

Patients presenting for airway surgery frequently have coexisting medical problems (often smoking-related); they may require optimization before surgery.

In the presence of acute-onset stridor, investigations should be kept to a minimum.

Emergency airway interventions should only be undertaken with an experienced ENT surgeon present.

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Airway surgery demands a high level of cooperation between surgical and anaesthetic teams. This article discusses anaesthesia for some common airway procedures and paediatric airway problems. In addition to facilitating surgery through providing an unobstructed and immobile operative field, anaesthetists must provide oxygenation, carbon dioxide elimination, adequate anaesthesia, and a rapid return of consciousness and airway reflexes after surgery.

General considerations

Evaluation of the location, size, extent, and mobility of any lesion is required. The effects on laryngeal function and airway patency must also be investigated. Previous anaesthetic and surgical findings are useful, though tumours may grow rapidly and radiotherapy can change tumour size, appearance, and mobility. Cross-sectional imaging helps to define upper and lower limits of lesions and nasendoscopy provides advance warning of their appearance.

The population presenting for airway surgery mainly falls into two categories. The first group comprises elderly patients with coexisting respiratory and cardiovascular morbidity resulting from long-term smoking and high alcohol intake. These patients often have malignant lesions and may show side-effects of its treatment (e.g. radiotherapy). They often require invasive intraoperative monitoring and short-acting opioids such as remifentanil. The second group comprises young children or those with learning difficulties who inhale or ingest foreign objects.

Psychosocial factors include fear of choking, death, and inability to communicate following tracheostomy. Many patients return for multiple procedures.

Intraoperatively the anaesthetist must pay special attention to protecting eyes, neck, and teeth while optimizing surgical access in what may be a crowded area.

Ventilatory techniques

The mode of ventilation depends on the type of surgery being undertaken and the access required to the operative site (see Table 1).

Spontaneous ventilation with topical anaesthesia ± sedation

While this allows patients to remain in control of their own airway there are very few procedures that patients are able to tolerate.

Spontaneous respiration with general anaesthesia

General anaesthesia for upper airway endoscopy can be given via a Storz bronchoscope (usually in paediatric practice).

Intermittent, positive-pressure ventilation

This is usually delivered using a microlaryngoscopy tube (MLT). This allows the use of standard anaesthetic equipment in normal operating mode. However, there is often reduced access to the surgical field and the tracheal tube obscures the posterior one-third of the glottis. The operative field is relatively mobile, moving with respiration.

Low-frequency jet ventilation (LFJV)

This is frequently delivered using a high-pressure gas source via a narrow cannula attached to a suspension laryngoscope or bronchoscope. Gas is delivered by operation of a hand-operated switch at a rate of ~10–20 breaths min^{-1}. This stream of high-velocity gas entrains air, increasing the tidal volume generated and diminishing the oxygen concentration of the inspired gas.[1] This allows the operating field to be immobile for short periods. LFJV is easy to perform, requiring uncomplicated anaesthetic equipment. It produces an unobstructed view of the operative field. However, there is a risk of barotrauma with use of a high-pressure gas system,

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Table 1 Modes of ventilation in airway surgery

Method of ventilation	Ventilate open airway	Operative field immobile	Specialized equipment needed	Airway pressure monitoring	Barotrauma risk	Gas entrainment	Airway gas monitoring
IPPV	No	No	No	Yes, reliable	↓	No	Accurate
Low frequency jet	Yes	No	Simple gas injector	Difficult, intermittently high	↑↑	Yes	Difficult
High-frequency jet	Yes	Yes	Yes, specialized ventilator	Yes, but only with specialized ventilators	↑	Yes	Difficult

especially if the jet is below the larynx. Therefore, the upper airway must remain patent. Despite chest movement being clearly visible, adequacy of ventilation is difficult to assess owing to the lack of end-tidal CO_2 monitoring.[2] Inhalational anaesthesia may not be delivered via LFJV, so total intravenous anaesthesia (TIVA) is required. Other disadvantages include movement of the operative field and gastric insufflation if the suspension laryngoscope is poorly aligned.

High-frequency jet ventilation (HFJV)

This is delivered via a narrow cannula attached to a suspension laryngoscope, a longer catheter placed sub-glottically or via a crico-thyroid cannula. Instead of a hand-held switch, the onset and offset of inspiration are controlled by a high-frequency flow interrupter (which may be pneumatically or electronically controlled). Air is still entrained, although generated tidal volumes are much smaller than those used in conventional ventilation. Parameters that may be altered include inspired oxygen concentration, driving pressure of gas, frequency of ventilation (usually 60–600 breaths min^{-1}), and inspiratory time (usually ~30% of the cycle).

This technique provides an improved view of an immobile operative field. However, TIVA and complex equipment are required, it is difficult to monitor carbon dioxide concentration, the airway is not protected by cuffed tube, and there is a risk of barotrauma. Gases tend to cool and dry the airway owing to large minute volume; ventilators have now been developed, which heat and humidify the gas and continuously monitor airway pressure.

Specific surgical procedures

Direct laryngoscopy

Direct laryngoscopy is performed to investigate and treat potential pathology in the upper airway and may or may not involve the use of an operating microscope. In the presence of an obstructing lesion, stridor at rest implies airway narrowing of at least 60%. Examination of the head and neck for evidence of external airway compression should be undertaken. Investigations may include x-rays of thoracic inlet, neck and chest soft tissues, computed tomography (CT) or magnetic resonance imaging (MRI) of the airway and flow-volume loops. A preoperative fibreoptic endoscopic examination (which may be performed using topical, nasal anaesthesia) is an extremely useful investigation, allowing formation of a joint management plan. Other preoperative considerations include the patient's general state of health and the presence of intercurrent disease such as silent reflux.

This type of surgery may cause a severe sympathetic-mediated stress response; 1.5–4% of patients show signs of cardiovascular ischaemia postoperatively. This stress response should be attenuated using short-acting opioids. The vocal cords are paralysed for the procedure then a rapid return of consciousness and airway reflexes is required after the termination of surgery to reduce problems occurring during the recovery period. Postoperatively, the main areas of concern are airway obstruction, bleeding, laryngospasm, and laryngeal incompetence.

Anaesthetic techniques for direct laryngoscopy include:

(i) *Local anaesthesia for fibreoptic endoscopic examination* (commonly nasendoscopy in the clinic setting). The small diameter of the nasendoscope often allows examination without any anaesthesia.

(ii) *Intermittent apnoea without endotracheal intubation*. This has the disadvantages of poor airway protection and poor control of depth of anaesthesia but the advantage of an unobstructed surgical view.

(iii) *General anaesthesia employing an MLT*. This is a common technique using a long, narrow, cuffed tracheal tube (e.g. 31 cm long, 4–6 mm internal diameter) to move the breathing system connections away from the airway and give a reasonable surgical view of the larynx. This allows conventional, positive pressure ventilation to be used. A cuff is inflated in the trachea, protecting the lower airway from contamination.

(iv) *Jet ventilation techniques*. These methods provide the optimal surgical view and reduce the degree of stimulation but there is no physical protection of the airway. There is a need for TIVA and paralysis, but the vocal cords may still impair gas egress, risking barotrauma. There may not be the facility to humidify and warm inspired gases. When used supraglottically there is a risk of gastric insufflation.[1]

Fibre-optic bronchoscopy

Fibre-optic bronchoscopy is most often performed in the outpatient setting by respiratory physicians. There is usually no

need for an anaesthetist; the operator uses a combination of topical anaesthesia and sedation and an anticholinergic drug as premedication to reduce saliva production.[3] Many departments have protocols for sedation and monitoring to improve patient safety.

If there is a need for anaesthesia, the fibrescope can be passed through an airtight seal into the breathing system. This may be through a mask, a laryngeal mask airway (LMA) or a tracheal tube. Small leaks may occur using these systems but they do allow gas analysis. Usually, the patients are left to breathe spontaneously. Anaesthesia may be delivered using inhalational or intravenous agents.

Rigid bronchoscopy

The rigid bronchoscope is used for diagnosis of lesions in the respiratory tract down to the main bronchus and therapeutic interventions such as dilation of tracheal stenosis, airway tumour resection, and foreign body removal. Preoperative identification of neck pathology is important since the atlanto-axial joint is extended almost maximally. There is a risk of damage to teeth and a bite guard should be employed.

Anaesthesia is induced and maintained intravenously (usually using propofol). Profound muscle relaxation is achieved with intermittent succinylcholine (combined with atropine to avoid bradycardia) or a short-acting non-depolarizing agent (e.g. mivacurium). Topical laryngeal anaesthesia and administration of a short-acting opioid will diminish the stress response to surgery during instrumentation.[4] Usually, LFJV is provided using a high-pressure oxygen source directed down the bronchoscope.

Foreign body removal

Patients requiring removal of a foreign body are often young children or adults with learning difficulties. Often, they are not fasted. The application of positive airway pressure may induce a valve effect (causing gas-trapping distal to the inhaled object) or may cause the object to migrate distally into a less accessible branch of the respiratory tree. An inhalational induction followed by spontaneous respiration is often employed until the foreign body has been removed.[5]

Tracheostomy

Urgent tracheostomy is performed for critical, upper-airway obstruction. It is also performed for threatened airway obstruction when tracheal intubation has failed or is predicted to be difficult. The National Confidential Enquiry into Patient Outcome and Death (NCEPOD) recommended that if there is evidence of critical airway stenosis then an experienced ENT surgeon should perform the procedure under local anaesthesia, maintaining airway patency until control is established.

These patients often do not tolerate a supine position and may need to remain sitting through the induction of anaesthesia or during the performance of tracheostomy. In the absence of critical airway stenosis, the tracheostomy may be performed after induction of anaesthesia. Percutaneous tracheostomy is usually carried out in Intensive Care Units, although, rarely, it may be performed in the operating theatre as an emergency.

Intraoperative problems include cuff perforation, loss of airway control due to difficult insertion of the tracheostomy tube (ensure pre-oxygenation prior to tube insertion), and airway fire (cutting diathermy should be avoided). Ensure that the tracheostomy tube is securely fixed as re-insertion is often difficult. A window or flap procedure as opposed to a slit approach to the trachea may reduce the frequency of problems with tracheal tube insertion.

Laser surgery

Risks include airway fire, damage to healthy tissue, and injury to theatre staff. There should be good teamwork in theatre. All staff must be familiar with laser surgery and local safety policies.[6] Nitrous oxide and high concentrations of oxygen support combustion and should be avoided. In practice inspired oxygen concentration is ~21%. There should be a 'fire-drill' in place so that all staff are prepared for an airway fire; there should be a pre-filled 50 ml syringe of 0.9% saline available.

Management options for the anaesthetist include:

(i) The use of specifically-designed laser tubes that resist damage and dissipate the high energy of the laser, thus diminishing the risk of tube fire and reflection damage to adjacent tissue. These tubes allow conventional positive pressure ventilation.
(ii) High-frequency jet ventilation gives an optimal surgical view but requires specialized equipment, expertise, and a TIVA technique.

There is a potential risk of cross-infection to theatre staff if papillomata are resected using a laser device due to aerosolization of virus-laden particles. Specifically designed masks are worn to reduce this risk.

Airway trauma

Airway trauma may be penetrating or blunt. It is often life-threatening and should be managed by senior anaesthetic and surgical personnel who should form a joint management plan preoperatively. Often there is limited time for assessment and investigation. Intermittent, positive-pressure ventilation or positive, end-expiratory pressure may cause dangerous subcutaneous emphysema. The airway may be secured after inhalational induction of anaesthesia. Conversely, general anaesthesia may be avoided prior to securing the airway using fibre-optic tracheal intubation or tracheostomy under local anaesthesia. *In extremis*, direct laryngoscopy and tracheal intubation with minimal anaesthesia may be deemed appropriate. The final choice of technique depends on the skill and experience of the available staff.

Table 2 Suggested contents of difficult intubation trolley

	Description Trolley
DRAW 1	Laryngoscope blades: Mackintosh 4 Miller 3 Miller 4 Polio Laryngoscope blade Mac 3 McCoy 3.5 Ventilating bronchoscope Standard laryngoscope handle Tooth guards
DRAW 2	Tubes: 5.5 ETT uncut 6 ETT uncut MLT #6, 7, 8, 9 reinforced LMA #3, 4
DRAW 3	Bougies: small medium stylets × 2 Airway exchange catheters × 2 Fibreoptic catheters × 2 Guide wire 3 mm J tip fixed core coated.
DRAW 4	Jet ventilation catheter 13G Crico-thyroidotomy kit adult Crico-thyroidotomy kit paediatric Retrograde intubation kit #22 fixed scalpel blade Curved haemostat Swabs
DRAW 5	Bite blocks Nasal airways #6, #7 Foam tipped O_2 catheter with anaesthetic machine connector
DRAW 6	Jet ventilator Fibrescope—with all parts present in holster

Tracheal resection

Tracheal resection is generally only performed in specialized units and a full examination is beyond the scope of this article.

Postoperative care

Following surgery to the airway, there is the risk of laryngeal spasm, aspiration, or airway obstruction due to oedema or haematoma formation. To minimize the risk of laryngospasm, the patients should be positioned semi-sitting and should have their trachea extubated either awake or under deep anaesthesia (to allow airway reflexes to return without the stimulus of the tracheal tube). In order to maintain airway patency following extubation under deep anaesthesia, a LMA can be used. A crico-thyroid cannula or orotracheal catheter may be left in place to facilitate emergency oxygenation during the recovery period.

Oedema may be reduced by the administration of dexamethasone intraoperatively. Nebulized epinephrine (2–3 ml of 1:1000) may be useful if stridor develops. If a small degree of airway obstruction develops during recovery then the use of helium may reduce the work of breathing and prove a useful short-term measure. Heliox contains 21% oxygen in helium; additional oxygen is often required. The risk of aspiration may be reduced by ensuring full reversal of neuromuscular blockade. To reduce the drying of the oral mucosa and the inspissation of secretions, humidified oxygen should be administered to all patients postoperatively.

The equipment required for emergency airway access should be available in recovery, and anaesthetic and surgical staff must remain nearby until the patient is ready for discharge. Difficult airway trolleys are a useful way of keeping emergency airway equipment readily available and it is recommended that one be present in the recovery area and that all members of staff be familiar with its contents (Table 2).

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Please see multiple choice questions 21–24.