REVIEW ARTICLE

# Special Considerations in Anesthesia for Laryngeal Cancer Surgery

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**Abstract**

The airway is not only shared but operated upon during laryngeal cancer surgery. Patients with laryngeal cancer may require general anesthesia for diagnostic endoscopic procedures, for endolaryngeal laser surgery or for major cancer resectional surgery. This review outlines the importance of careful assessment of the airway and medical comorbidities and discusses the options for anesthetic and ventilatory management whilst ensuring a safe airway, adequate oxygenation and the best possible view of the surgical field. Laryngeal cancer surgery may improve the airway or create new problems and the need for meticulous planning, multidisciplinary input, good communication and close cooperation between all members of the team is emphasized.

**Keywords:** Head and neck cancer surgery, Otolaryngological larynx anesthesia.

Laryngeal cancer is one of the top twenty most common cancers in UK males with 1,844 new cases diagnosed in 2007.[1] Laryngeal cancers may arise from the supraglottis (epiglottis, aryepiglottic folds, arytenoids and false cords), the glottis (vocal cords, anterior and posterior commissures), and the subglottis (lower border of glottis to lower border of cricoid cartilage). Patients with laryngeal cancer may require general anesthesia for minor diagnostic procedures, such as laryngoscopy and biopsy to assess the site and extent of disease, for endolaryngeal laser surgery, or for major cancer resectional surgery. The patient with a potentially difficult airway and multiple medical comorbidities combined with the necessity to share the airway with the surgical team poses many challenges to the anesthetist.

## PREOPERATIVE ASSESSMENT

### Assessment of Medical Comorbidities

Most patients present in the sixth to eighth decade of life and there is a preponderance of male smokers. The combined effect of smoking and alcohol consumption is estimated to account for 89% of laryngeal cancers[2] and careful consideration must be given to the management of pre-existing cardiovascular disease. The European Society of Cardiology 2009 guidelines offer useful advice on the preoperative risk assessment and perioperative management of cardiac disease.[3] Of the cardiovascular risk factors, congestive cardiac failure appears to have important prognostic significance for major surgery[4] and must be well controlled preoperatively. Unstable coronary syndromes, significant arrhythmias and severe valvular disease are also major clinical risks and must be intensively managed, if time allows before surgery. Most cardiac medications should be continued throughout the perioperative period.

Chronic obstructive pulmonary disease is common in these patients and careful history taking and examination are necessary to ascertain and optimize reversible elements of respiratory disease. Cough, sputum production and hemoptysis are common symptoms. Dyspnea from upper airway obstruction must be differentiated from dyspnea due to chronic airways disease and pulmonary function tests together with flow-volume loops are useful in this regard. Arterial blood gas analysis is useful to define gas exchange problems and plan postoperative ventilatory management. Preoperative steroids, bronchodilators, smoking cessation and chest physiotherapy may be beneficial.

Important considerations with chronic alcoholism are the deranged liver function and coagulation, altered drug handling due to hepatic enzyme induction, metabolic effects (hypokalemia, hypomagnesemia), anemia, and neurological

sequelae. Problems with alcohol withdrawal perioperatively should be anticipated early.

### Airway Assessment

Airway assessment is of paramount importance in determining the choice of anesthetic and airway management techniques. Difficulties in airway management occur due to a combination of anatomical and pathological features. It has been estimated that the incidence of difficult intubation ranges from 0.5-2% in the general population, from 8-10% in patients having ENT surgery, and rises to 28% in patients with tumors of the airway.[5] Glottic cancers are the commonest (50-60%) and they often present early with the cardinal symptom of hoarseness (dysphonia). Hoarseness is usually a late symptom with supraglottic tumors. Other common presenting symptoms include dysphagia, odynophagia, cough, pain due to cartilage invasion, and neck mass.[6] Positional exacerbation of airway symptoms is often due to supraglottic or pedunculated glottic tumors that stay clear of the glottic aperture when the patient is upright and pharyngeal tone is intact. Some patients may present with sleep disturbance and a recent multicenter trial suggested that 2.4 per 1000 patients who snore have an upper airway tumor or cyst.[7] A history of waking up at night in panic with breathing difficulties may suggest a critical obstruction.[8] Dyspnea and stridor due to airway obstruction occur with advanced disease.

The assessment of the airway should include an assessment of mouth opening (radiotherapy may limit jaw motion), Mallampati score as modified by Samsoon and Young[9] (a predictor of the difficulty of intubation, based on the visibility of structures within the oral cavity), laryngoscopic view at previous operations, neck movement, and prominent teeth. An examination of the neck structures for masses, scarring from previous surgery, and immobility of the larynx from previous radiotherapy will provide valuable additional information.

Preoperative nasendoscopy with a 2.7 mm endoscope, which requires no more than simple preparation of the nose with local anesthetic and a vasoconstrictor, is essential to assess airway diameter, location, size, nature and mobility of tumor (e.g. pedunculated), vocal cord movement, pooling of secretions, and importantly, to assess the risk of potential airway obstruction.

Radiographic images, commonly in the form of CT, MR and chest X-rays help in defining the primary site and assess extralaryngeal and nodal spread of disease. Computed tomographic images may be reconstructed to give 3 dimensional images of the lesion providing accurate anatomical information preoperatively.[10] Cross-sectional imaging techniques are the most useful in confirming intrinsic compression of the airways, a feature that may not be appreciated on endoscopic analysis alone.[11]

## MICROLARYNGOSCOPY AND BIOPSY

Careful discussion of the relevant clinical details, planning of appropriate technique, and cooperation between anesthetist and surgeon are essential. The anesthetist is required to ensure an adequate unobstructed airway, maintain oxygenation and $CO_2$ clearance, and prevent soiling of the airway whilst providing the surgeon with an unobstructed view and a motionless field. The choice of technique will depend on the patient's clinical condition, local expertise, availability of equipment, and the location, size, mobility and vascularity of the tumor. The airway management options can be broadly divided into 'closed' and 'open' methods.

For nonobstructing lesions, a technique that is familiar to most anesthetists is preoxygenation and intravenous induction followed by the placement of a cuffed microlaryngeal tube (internal diameter 5.0 mm) facilitated by a short acting muscle relaxant. The advantages of this type of 'closed' system are that the lower airway is protected from soiling and it allows greater control of ventilation with minimal environmental pollution. Spraying the larynx with lidocaine prior to tracheal intubation reduces the risk of laryngospasm and allows smoother postoperative recovery. The main disadvantages are poor surgical access, particularly to tumors involving the posterior commissure, high inflation pressures and inadequate ventilation because of patient factors combined with the high resistance of small diameter tubes. A 'closed' technique using a laser resistant flexometallic tube may be used for laser surgery. However, although the internal diameter of these tubes may be small, their outer diameter is large (e.g. Mallinckrodt Laser Flex tube, internal diameter 5.0 mm—outer diameter 7.5 mm) and they may impede surgical access.

An 'open' system for airway management allows improved surgical access. Various such systems have been described, including spontaneous ventilation/ insufflation, jet ventilation, intermittent apnoea and negative pressure ventilation.

The spontaneous ventilation technique allows an unobstructed view and prevents tube related damage to the glottis but leaves the lower airway unprotected. Inhalational induction with sevoflurane in 100% oxygen is followed by spraying of the glottis with lidocaine under direct vision. Spontaneous ventilation continues and surgery commences when an adequate depth of anesthesia is achieved. Anesthesia may be maintained either by a total intravenous technique or by volatile anesthetic agents delivered through a nasopharyngeal airway or catheter that is used for oxygen insufflation. Alternatively, if a rigid bronchoscope is used, the anesthetic delivery system may be attached to the side arm.

Several methods of 'jet' or 'injector' ventilation, more accurately termed high pressure source ventilation (HPSV), have been described. These techniques may be used where the disease is at an early stage and there is no obstruction to expiration. HPSV can be delivered by the supraglottic, subglottic or transtracheal routes, each of which has its advantages and limitations. A venturi needle may be attached to the suspension laryngoscope and targeted on the laryngeal inlet to provide supraglottic jet ventilation. The view for the surgeon is unobstructed but the disadvantages include movement of the vocal cords, risk of barotrauma, misalignment resulting in poor ventilation and gastric distension, and the risk of tumor fragments, blood and other debris being driven into the distal airways.[12] Subglottic jet ventilation is achieved by passing a specially designed jet ventilation catheter (e.g. Hunsaker Mon-Jet tube, Jockjet tube) through the glottis, into the trachea. The advantages of this technique include better minute ventilation and no movement of the vocal cords. Although previously beset by the greater risk of barotrauma when compared with the supraglottic jet ventilation techniques, the ability to monitor end tidal $CO_2$ and end tracheal pressure with newer equipment has enabled the safe provision of excellent surgical conditions with subglottic jet ventilation.[13] Transtracheal HPSV may best be performed via a catheter placed through the cricothyroid membrane which minimizes the risk of bleeding.[14] Transtracheal jet ventilation has been shown to have a significantly higher complication rate than the transglottic techniques.[15] Barotrauma is usually associated with airway obstruction and catheter migration may result in subcutaneous emphysema due to gas delivery into tissue planes between skin and the anterior tracheal wall.

The earliest description was the use of the Sander injector which is attached to an open rigid bronchoscope.[16] This relies on low frequency (8-10 per minute) jetting of oxygen at a driving pressure of 4 bar and air entrainment. The newer Manujet III (VBM Medizintechnik GmbH) can be used in a similar way but allows greater control over inspiratory pressure. Modern jet ventilators allow high frequency jet ventilation (HFJV) at rates of 100-150 per minute, and provide both humidification and the facility to set a pause pressure which minimizes air trapping and the potential for barotrauma. The advantages of HFJV include better gas mixing and diffusion within the lungs, reduced airway pressures, and continuous expiratory flow which improves the removal of tumor debris, secretions and blood.[12] A total intravenous anesthetic technique supplemented with short acting opioids and muscle relaxants, and local anesthetic spray to the larynx is used to provide maintenance of anesthesia and smooth recovery.

A national survey conducted in the UK in 2006 identified serious morbidity and 3 deaths over a 5 years period associated with the use of high pressure source ventilation during elective laryngeal surgery.[17] The most serious complications occurred during the use of manual ventilation techniques. The use of modern computer controlled jet ventilators that incorporate high pressure monitors, alarms and automatic cut off devices along with expired gas monitoring[13] improve safety with these techniques. The risks of barotrauma during jet ventilation are reported to be highest in situations where there is an obstruction to expiration and it is recommended that the anesthetist be vigilant in clinically verifying the unobstructed outflow of gas after each inspiration to prevent barotrauma.[15]

The laryngeal mask is a versatile airway adjunct and can be used following induction of general anesthesia to provide a safe airway before the surgeon introduces the rigid bronchoscope through which subsequent jet ventilation takes place. Its use in emergency situations with airway obstruction has also been reported.[18,19] Postoperatively, it may play a role in the emergence strategy as it provides an airway conduit through which continuous positive airway pressure (CPAP) can be applied.

Intermittent apnoea techniques have been described but are seldom used nowadays. General anesthesia is induced and after administration of a short acting muscle relaxant, the patient is briefly hyperventilated with a volatile agent in 100% oxygen using either a bag-valve-mask system or a

tracheal tube. The tracheal tube is then removed and the surgeon carries out the endoscopy with an unobstructed, immobile field. After a short period of 2-3 minutes of apnoea, the patient has to be reoxygenated before surgical access can be regained. The disadvantages are the interruptions to surgery, the unprotected airway during surgery if facemask ventilation is used, and potential trauma from multiple reintubations.

## THE OBSTRUCTED AIRWAY

Stridor is a medium pitched respiratory noise caused by partial obstruction of the upper airway and occurs when upper airway diameter is reduced by 50% or more.[8] Stridor due to glottic and subglottic lesions tends to be biphasic whereas lesions above the vocal cords generally produce inspiratory, and intrathoracic lesions generally produce expiratory stridor. The volume does not correlate with the size of the lesion or the extent of obstruction. Treatment of stridor includes humidified oxygen, nebulized adrenaline and intravenous dexamethasone. Heliox (Helium 79%, Oxygen 21%) has a lower density which results in increased laminar flow across the obstruction and a decrease in the work of breathing. There is, however a trade off between the improved flow profile and the lower inspired oxygen concentration. An experienced surgeon and an experienced anesthetist need to make a judgement about whether tracheal intubation will be possible based on clinical and nasendoscopic assessment. If intubation success is judged to be unlikely, a tracheostomy is performed under local anesthesia to establish an airway. These can be difficult in patients who are often extremely anxious, unable to lie flat and struggling for every breath. It may be possible to add a small amount of sevoflurane judiciously to the 100% oxygen to provide an element of sedation to supplement the local anesthesia.

If it is felt that there is a reasonable prospect of successful tracheal intubation, the main options are an inhalational induction with direct laryngoscopy and tracheal intubation, or an awake fibreoptic intubation. Intravenous induction of anesthesia and the use of a muscle relaxant are not recommended in this situation. Impending airway obstruction may not be obvious, but supraglottic tumors may cause obstruction upon induction of anesthesia and muscle relaxation. If facemask ventilation then proves difficult in the face of apnea, the effects of the intravenous drugs cannot be easily reversed. Both inhalational induction and awake fibreoptic intubation have their pros and cons and the decision must take into consideration both the clinical situation and operator experience. No technique should be undertaken without an experienced ENT surgeon scrubbed and ready, with access to a rigid bronchoscope and a tracheostomy set.

The aim of an inhalational induction is to maintain spontaneous ventilation until sufficient depth of anesthesia is obtained to allow direct laryngoscopy and visualization of the glottis. Halothane was for many years the agent of choice for this technique but had the drawback of causing cardiac arrhythmias at high concentrations and was also associated with a small risk of hepatotoxicity on repeated administration. Sevoflurane is now commonly used and allows rapid, smooth induction of anesthesia due to its pleasant odor, lack of airway irritation and low blood gas solubility. Inhalational induction may be difficult because respiratory obstruction often occurs when the patient initially loses consciousness and there may be breath holding, coughing and laryngospasm upon instrumentation (e.g. insertion of Guedel airway). Moreover, there is often a large increase in the work of breathing and the increased negative intrathoracic pressure during inspiration may result in collapse of the airway distal to the obstruction which decreases gas transfer and causes delay in reaching an adequate depth of anesthesia to allow airway intervention. Although the safety of inhalational induction is thought to lie in the maintenance of spontaneous ventilation there are times when the judicious use of gentle positive pressure can overcome this airway collapse and speed induction. When anesthetic depth is adequate laryngoscopy is undertaken and a rapid decision is made as to whether intubation is possible. If a standard Macintosh laryngoscope does not provide an adequate view of the glottis, a second attempt may be made with a different instrument (e.g. McCoy, straight blade, anterior commissure laryngoscope) or a different approach (e.g. paraglossal). The place of the newer video-laryngoscopes remains to be defined. A rigid bronchoscope may be used by an experienced surgeon to provide a temporary airway or to position a bougie over which a tracheal tube may be passed. Should sudden, complete airway obstruction supervene, immediate tracheostomy must be undertaken.

If an adequate glottic aperture can be visualized with the nasendoscope with the patient awake and in the sitting position, it may be reasonable for an experienced

endoscopist to undertake an awake fibreoptic intubation. It is important to remember that the view of the glottis with the patient asleep and supine is likely to be different. Sedation can be carefully titrated to maintain spontaneous ventilation with target controlled infusions of remifentanil or propofol or both but oversedation is dangerous. Local anesthesia is difficult to achieve and may provoke laryngospasm, instrumentation may cause hemorrhage, and passage of the fibrescope itself may obstruct an already narrowed airway.[20]

## MAJOR LARYNGEAL CANCER SURGERY

Although regional anesthesia for major neck surgery has been described,[21] general anesthesia is required for most patients undergoing surgery for laryngeal cancer. The principles guiding the selection of anesthetic induction technique and airway management for major surgery are similar to those for microlaryngoscopy procedures described above. The decision will be influenced by patient factors and surgical requirements. Insertion of a prophylactic transtracheal catheter via the cricothyroid membrane under local anesthesia allows high frequency jet ventilation of the lungs with oxygen whilst the airway is secured by either conventional direct laryngoscopy under general anesthesia or fibreoptic intubation. This may avoid the need for primary tracheostomy insertion.[22] Importantly, the airway has to be protected and maintained for a number of hours and often the patients have an end stoma sited at the end of the surgery.

The patient is usually positioned in a 15-20° reverse Trendelenberg position to minimize venous congestion and aid surgical access. This increases the possibility of venous air embolism. The eyes must be padded and peripheral nerves protected from compression injuries during these long procedures. The anesthetist is remote from the head end of the operating table and consideration must be given to long ventilator tubing, sampling lines, and appropriate monitoring equipment. In addition to standard non-invasive monitoring, an arterial line and urinary catheter are required for intraoperative management. Patients' comorbidities will dictate the need for central venous pressure monitoring, the antecubital fossa or the femoral vein being the preferred routes. Most of the ventilator tubing and vascular access lines lie underneath the drapes and all connections must be carefully secured. Laryngeal surgery, particularly when combined with radical neck dissection, can take many hours and the use of a humidifier, warmed intravenous fluids, and a forced air warming system together with temperature monitoring are recommended.

Maintenance of anesthesia may be provided by volatile anesthetic agents or total intravenous anesthesia (TIVA). TIVA typically comprises an infusion of the rapidly distributed anesthetic agent propofol, in combination with an opioid, and is ideally administered via a cannula that is visible at all times in order to prevent awareness from intravenous line failure or disconnection. Remifentanil and alfentanil are both short acting opioids suitable for use in this context. Remifentanil is a potent drug with rapid and predictable elimination regardless of the duration of its administration and has been shown to maintain cardiovascular stability and rapid, uneventful emergence during microlaryngeal surgery when combined with sevoflurane.[23]

The attenuation of cardiovascular responses (bradycardia, tachycardia, hypertension, cardiac arrhythmias) to the prolonged manipulation of the upper respiratory tract is important to consider. Baroreceptor stimulation occurs during surgery and coronary artery spasm provoked by carotid sinus stimulation has been reported.[24] Large bore venous access is necessary as bleeding from the large blood vessels in the neck may be significant. Much of the blood loss is often hidden underneath the drapes and may not become apparent until the end of surgery.

A particular risk of endolaryngeal laser surgery is the potential for an airway fire caused by the high energy laser beam, combustion being supported by the anesthetic gas mixture. This can be minimized by the use of laser resistant or laser proof tubes which are typically made of flexible stainless steel with corrugated surfaces that diffuse the laser beam. Some tracheal tubes used in laser surgery have two saline filled cuffs and in case one punctures the other provides protection.

For those patients undergoing laryngeal surgery not requiring an end stoma a careful extubation strategy should be planned well in advance. Swelling after prolonged surgery, bleeding and airway debris make extubation hazardous. If tracheal intubation was difficult in the first place, reintubation in suboptimal circumstances is likely to be more. Extubation over a small airway exchange catheter is worth considering as it is relatively easier for the patient to tolerate and facilitate rapid reintubation if the need arise. Supraglottic laryngectomy offers the advantage of cure with preservation of speech for certain types of tumor and a temporary tracheostomy may be considered for immediate postoperative management.

Postoperative care should be undertaken on a ward with specialist staff capable of managing problems associated with tracheostomies and airway emergencies, or on a high dependency ward. Analgesic requirements can be met with an IV morphine PCA system, supplemented with paracetamol and nonsteroidal anti-inflammatory drugs. Careful management of the tracheostomy is necessary in the immediate postoperative period with humidified oxygen to minimize crusting, and frequent suction to keep the airway clear of blood and secretions. Patients should be nursed in the semierect position to improve venous drainage, reduce swelling and improve respiratory mechanics with attention paid to fluid balance and nutritional requirements.

## CONCLUSION

Patients presenting for laryngeal cancer surgery present particular challenges for the anesthetist. They are elderly, often have significant coexisting medical problems and have abnormal airways that have to be shared with the surgical team. As far as is possible, the level and the full extent of the airway difficulty must be defined. As no single technique is 100% effective, the primary plan for airway management and the back-up plans need to be discussed and agreed between the anesthetic, surgical and theater teams. Thorough preoperative assessment, the availability of specialized equipment and experienced staff, and close cooperation between team members must be ensured. Careful planning and meticulous attention to the details of perioperative care are necessary to achieve successful outcomes for these patients.

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