Multidisciplinary difficult airway challenges: Perioperative management of glottic and supraglottic tumors


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Carcinomas of the larynx are common and require multidisciplinary perioperative management, with particularly excellent communication between the surgeon and anesthesiologist. Early preoperative assessment allows for optimization, prehabilitation and advanced imaging in cases who present without respiratory compromise. On arrival for surgery, thorough airway examination including preoperative endoscopic airway assessment under topical anesthesia and airway ultrasound will inform planning for airway management. The fundamental decision between awake tracheal intubation or awake tracheostomy, and intubation after induction of anesthesia should be made as a team, with strategies for failure (such as rigid bronchoscopy or emergency surgical airway) clearly defined, and staff and equipment present. Balanced total intravenous anesthesia with target-controlled infusions allow good analgesia and smooth emergence. Admission to a postanesthesia high care environment is advisable.

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Introduction

Carcinoma of the larynx accounts for approximately 1% of all cancers. The facial structures, upper airway, larynx and proximal trachea may also be afflicted by papillomas, haemangionomas, chordomas, sarcomas, and rarer forms of neoplasia. By interfering with basic functions of daily life such as speech, swallowing and respiration, these tumors are particularly distressing and disfiguring, and carry significant morbidity and mortality for the afflicted. In many parts of the world these patients present with advanced disease, and despite advances in early diagnosis and surgical treatment, they can be very challenging to manage. A multidisciplinary approach which includes otolaryngologists, oncologists, anesthesiologists and allied professionals is essential to ensure a smooth transition through the perioperative period, optimizing outcomes and minimizing discomfort without compromising safety at any time.

Once the decision to operate on a glottic or supraglottic tumor has been made, the patient must undergo several sequential stages of preoperative assessment, optimization...
and/or prehabilitation, preparation for anesthesia, induction and initial airway management, intraoperative surgical and anaesthetic care, emergence, and immediate postoperative care. While the treatment of each patient should be individualized by the specialists involved, the application of broad principles and protocolized checks in each phase will help maximize perioperative wellbeing.

**Perioperative management of glottic and supraglottic tumors**

Surgical interventions for glottic and supraglottic tumors include panendoscopy, biopsy, cold steel or laser debulking or resection, laryngectomy with or without neck dissection, reconstructive procedures with pedicled or free flaps, and tracheostomy. Patients may present with airway compromise requiring urgent airway intervention or may only develop airway obstruction during anesthetic induction. The latter applies especially to supraglottic tumors. Surgical interventions occur anywhere in the spectrum of situations from the true life-threatening emergency—where the patient presents in severe respiratory distress due to impending complete airway occlusion necessitating simultaneous management and clinical decision-making—to the elective setting in which careful assessment and planning for surgery and adjuvant treatment is possible. The foundation, however, remains excellent communication between the surgeon and anesthesiologist, with involvement of the patient in the decision-making process as fully as possible. For instance, where endoscopic assessment of the airway has been performed by the Ear, Nose and Throat surgeon at the time of diagnosis, it is immensely valuable to clearly document and communicate these findings to the anesthesia team. This will alert them to anticipate difficulties with intubation due to distortion of the upper airway, possible bleeding during manipulation, and obstruction with loss of ability to ventilate during induction.

**Preassessment, optimization and prehabilitation**

The early involvement of a multidisciplinary team which includes anesthesia preassessment is desirable, despite the practical challenges. Early preoperative assessment allows for risk stratification, judicious requests for further investigations, and planning for preoptimization/prehabilitation. Ironically, resource-constrained systems in which there are delays of weeks or months from diagnosis to surgery offer the advantage that patients can be prehabilitated before surgery, with concomitant improvements in chronic disease control, nutrition, smoking cessation and effort tolerance. Although the evidence in Ear, Nose and Throat surgery is still forthcoming, the role of prehabilitation is increasingly evident in other major surgery. Any available time should be used to address chronic co-morbid diseases, undergo lifestyle modification, and improve fitness.

Special investigations should be limited to those which will either directly influence risk-modulation decisions or allow for patient optimization. For instance, preoperative hemoglobin and iron studies may prompt supplementation that avoids transfusion. Although a staple in the assessment of airway lesions for many years, the role of routine pulmonary function testing (PFT) is debatable in the era of detailed 3-dimensional imaging. PFT was historically used to identify the type/level of airway compromise. However, in the case of glottic and subglottic tumors, this is already known to be extrathoracic, and the distinction between dynamic and static lesions is less useful. Furthermore, PFTs in distressed patients are not reproducible and often unhelpful. Detailed computed tomographic (CT) or magnetic resonance imaging (MRI) scans, in contrast, can provide detailed anatomical details which not only guide the planning of surgery and allow prognostication, but can assist the anesthesiologist with planning an airway management strategy, including selecting the type and size of airway devices (Figure 1). It should be borne in mind, however, that any delay between imaging and surgery could allow time for tumor growth and progression; the strategy must remain flexible.

An emerging benefit of CT or MRI imaging is the ability to create virtual 3-dimensional models which can be examined, or used for virtual endoscopy (VE). VE allows the clinician to navigate a reconstruction of the airway, either using a standard computer interface, or via a flexible bronchoscopy simulator. In this manner, it is possible to “practice” flexible endoscopic intubation and anticipate difficulty prior to performing the procedure on the patient. In the future, the use of virtual or augmented reality interfaces may extend this to an immersive environment, or even to the bedside.

Arterial blood gas analysis is useful in the setting of severe underlying lung disease or where airway compromise or respiratory distress is present, but should not be considered a routine investigation. It is more useful in the
Preparation for anesthesia

Due to the likelihood of advanced maneuvers to secure the airway, preoperative fasting according to the accepted local or international guidelines is advisable. Patients may benefit, however, from administration of clear preoperative carbohydrate drinks to limit the duration of perioperative catabolism. An anxiolytic premedication may be provided if required, bearing in mind potential interactions with analgesodation for awake airway management. As many cases will be performed with target-controlled infusions (TCI), total intravenous anesthesia (TIVA), or may require vasopressor infusions, we routinely establish 18G intravenous (IV) access on the arm ipsilateral to the anesthesia workstation, using a multiport "clave" IV set which includes nonreturn valves to prevent inadvertent retrograde flow of infusions. Intra-arterial access is only obtained (usually via the ipsilateral radial artery but with allowances for the donor site if radial forearm flap is planned) where there is indication for continuous blood pressure monitoring, expectation of significant blood loss, severe underlying cardio-respiratory disease, or where frequent blood sampling is anticipated. Arterial access prior to induction is very useful in the frail and where highly stimulating panendoscopy precedes intubation, but where only required for intra- or postoperative monitoring, can be performed under anesthesia.

Where preoperative endoscopic airway examination (PEAE) will be performed (see below), it is advantageous to promptly commence topicalization of the airway with nebulized lidocaine and vasoconstrictor (4% lidocaine with adrenaline or phenylephrine is used in our practice). Should an awake technique already be planned, this forms part of the preparation, which can occur in parallel to the loading of an intravenous analgesodative (such as dexmedetomidine) in the preanesthetic/induction room. Administration of a modest dose of antiallogue (eg, glycopyrrolate 1-2 mcg/kg) before topicalization is common, and may help prevent alpha-adrenergic-induced bradycardia.

Airway assessment in patients with glottic and supraglottic tumors

As for any procedure, a detailed preoperative assessment by the anesthesiologist must be performed, including a focused history and careful physical examination of the airway. Features of anamnesis which are particularly elucidative include presence/onset/duration of vocal changes, difficult glutation, previous head and neck procedures (including radiotherapy), positional symptoms, and effort tolerance. Examination should certainly include assessment of neck mobility, mouth opening, physical obstruction due to the lesion, displacement and/or mobility of the laryngeal structures, and impingement due to soft tissue mass. Routine protocolised documentation of adequacy of interincisor, thyromental and thyrohyoid distances, denticion, mandibular protrusion (and/or upper lip bite test) and neck circumference will help to alert the practitioner to difficulty.

Patients who present with clear indications for awake tracheal intubation independent of the tumor (such as very limited mouth opening, fixed neck flexion, and in particular previous radiotherapy to the neck even if there is no obvious fibrosis and scarring) should warrant at least awake endoscopy/PEAE, but there should be a low threshold to simply continue with awake flexible endoscopic intubation. Supraglottic tumors which are not navigable during PEAE warrant serious consideration of awake tracheostomy as a primary strategy.

It is challenging to assess the degree to which the airway patency will be degraded during induction of anesthesia by standard airway examination alone. While experience shows that glottic tumors often do not cause obstruction to ventilation on induction, they may hinder laryngoscopy and prevent placement of a rescue supraglottic airway device (SGA). Lesions of the larynx and supraglottic region often do cause deterioration or complete obstruction on induction, and while a small endotracheal tube (ETT) or microlaryngoscopy tube (MLT) might be forced through in an emergency, this carries the risk of trauma and/or hemorrhage. Conversely, patients who have undergone prior head and neck surgery or radiation may have predictors of difficulty on routine airway examination (such as scarring or limited neck movement) which in fact do not cause impediment to ventilation or intubation in that specific case.

To pre-empt these situations and assess the degree/likelihood of obstruction, several authors have recommended the performance of preoperative endoscopic airway assessment at the time of arrival for surgery, even if prior diagnostic endoscopy has been documented by the surgeon. PEA can be rapidly and safely performed under topical anesthesia in the induction room (or operating theatre) by either the anesthesiologist or surgeon (or ideally as a team). With a small-diameter flexible scope, it is well tolerated by patients, as they have frequently already undergone the procedure in the clinic. Grading of the airway by endoscopic view as per the five categories of Moorothy et al (Table 1) can be useful for documentation, communication and guiding decisions on an airway strategy. While this may be perceived to be an additional step which will result in delays, it has been shown in a prospective study to reduce the number of awake intubations which are required (in favor of performing video laryngoscopy under anesthesia) while improving patient safety. Furthermore, by encouraging early PEAE under topical anesthesia, the patient is already partially prepared for awake intubation if this is deemed necessary.
Table 1  Grading of the airway on PEAE (adapted from Moorthy et al\textsuperscript{[27]})

<table>
<thead>
<tr>
<th>Grade</th>
<th>History</th>
<th>Features on PEAE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 0</td>
<td>No hoarseness of voice</td>
<td>Normal larynx</td>
</tr>
<tr>
<td>Grade 1</td>
<td>Smoking history without hoarseness</td>
<td>Small lesion(s) such as polyps, papillomas or leukoplakia. Vocal folds fully visible (analogous to Cormack-Lehane grade 1)\textsuperscript{13,44}</td>
</tr>
<tr>
<td>Grade 2a</td>
<td>May have hoarseness</td>
<td>Vocal folds fully or partially visible. Tumor, cyst or papillomas are visible and causing oedema or anatomical distortion without obstructing view (analogous to CL 2a).</td>
</tr>
<tr>
<td>Grade 2b</td>
<td>Hoarseness without respiratory difficulty</td>
<td>Partial view of vocal folds, with one or more tumors or cysts encroaching on larynx and causing obstructed view or anatomical distortion (CL 2b analogue).</td>
</tr>
<tr>
<td>Grade 3</td>
<td>Hoarseness and respiratory difficulty</td>
<td>Vocal folds difficult to see due to obstruction/oedema; laryngeal opening may be seen with inspiration but is mostly obstructed (CL 3 analogue).</td>
</tr>
<tr>
<td>Grade 4</td>
<td>Significant vocal changes and/or respiratory difficulty</td>
<td>Large tumor causing obstruction. Vocal cords and laryngeal opening cannot be identified with flexible endoscopy. (CL 4 analogue)</td>
</tr>
</tbody>
</table>

Figure 2  Ultrasound at the level of the thyroid cartilage, showing tumor mass displacing trachea posteriolaterally.

Figure 3  Endoscopic view of a tumor of the supraglottic larynx that may cause obstruction during induction of anesthesia. (Moorthy grade 3 or 4, depending on dynamic movement.)

Where significant difficulty is expected (eg. Moorthy grades 3 or 4; Figure 3) and an emergency surgical airway may be required, it is advisable to infiltrate the anterior neck over the cricothyroid membrane and potential tracheostomy site with a mixture of local anesthetic and vasoconstrictor (such as dilute adrenaline), and to inject local anesthetic into the tracheal lumen. This is best performed at the time of airway ultrasound, which then confirms the infiltration site and assists in avoiding blood vessels and the tumor itself, although the central neck is relatively avascular apart from the thyroid isthmus.\textsuperscript{24,27,28} Should the cricothyroid membrane (CTM) be accessible, it is also feasible to perform a transcricoid injection of local anesthetic to assist with airway topicalization. Some authors recommend performing this with an IV cannula which is then left in place through the CTM to allow jet insufflation, or the passage of either a retrograde intubation guidewire or percutaneous tracheostomy kit. It is advisable, however, to avoid traversing the cancer, and hence a tracheostomy is generally preferred to a cricothyroidotomy.
Anesthetic induction and airway management

The fundamental decision from which the rest of the airway (and indeed, much of the anesthetic) strategy follows is whether to manage the airway awake, or if it is safe to induce anesthesia and then intubate the patient. It requires clear discussion between the anesthetist and the otolaryngologist, as resorting to an operating laryngoscope, rigid bronchoscope or swift tracheostomy may be required with large supraglottic or hypopharyngeal tumors. Inhaled induction and laryngoscopy during spontaneous ventilation has been associated with a concerning rate of failure and loss of airway patency in the literature (10%-75%).

Unless there is significant experience with the technique, it should be avoided where the risk of obstruction exists. Most airway algorithms suggest the use of supraglottic airway devices (SGAs) for rescue of failed intubation, but it must be recognized that SGAs require adequate mouth opening for insertion, absence of significant obstruction, and relatively normal anatomy to seal adequately. Similarly, the direct obstruction or displacement of the larynx or trachea by a tumor must be recognized when considering front-of-neck rescue. Hence, patients should not be anesthetized prior to securing the airway unless there exists both a reasonable expectation of being able to intubate without severe difficulty, and of being able to oxygenate and ventilate adequately with a face mask. PEAE will inform both (especially the former) criteria. The "impossible" patient who cannot safely be induced but also presents major difficulty for awake intubation or tracheostomy can be considered for establishment of extracorporeal oxygenation under local anesthesia.

Anesthesia prior to intubation

If the patient can be safely induced, the choice of agents and airway strategy is broad. Excellent preoxygenation (possibly supplemented by an apnoic oxygenation strategy; see below) must be routine. Propofol (for induction or as part of a TIVA) is useful in blunting airway reflexes. If used, neuromuscular blockade is ideally rapid-acting. Intubating conditions with adequate doses of rocuronium are comparable to succinylcholine, and it may be reversed more rapidly where sugammadex is available. However, the "fool’s paradise" of using either agent in the expectation that it will be reversed within an adequate time to rescue a “cannot intubate, cannot oxygenate” (CICO) scenario must be avoided.

As most glottic and supraglottic tumor cases meet the definitions of a difficult airway, there is a clear role for video laryngoscopy (VL). VL not only improves ability to see the larynx when laryngoscopy is challenging, but also turns the intubation into a team effort. Large glottic tumors are often easily circumnavigated with hyperangulated VL blades. Several caveats should be noted. Firstly, VL requires additional training and practice to master, and subtly different techniques when using different blade types. Secondly, an introducer (stylet or bougie) should always be used, to assist with steering the tube when it is not under direct vision. This avoids the common complaint that the view with a VL is excellent, but passage of the ETT is difficult or impossible. However, care must be taken not to injure friable tumors and cause bleeding or false passages. Thirdly, the anesthema of VL is blood or secretions on the camera lens, so the VL should be used in a "high and dry" approach that involves gentle gradual insertion with suctioning as required. Supraglottic/laryngeal tumors are amenable to the use of Macintosh-shaped VL blades, which do offer the possibility of switching to direct laryngoscopy if the lens becomes soiled ("VLDL").

Intubation under anesthesia with challenging tumors can be greatly enhanced with the use of "dual endoscopy." Here, direct or video laryngoscopy is complemented by an optical or video stylet (such as the Bonfils, Shikani or CMAC VS) in the endotracheal tube. This allows 3 levels of assistance. Firstly, the stylet acts as an introducer, improving ability to pass the ETT when an adequate view is obtained. Secondly, when the larynx cannot be seen on laryngoscopy due to the tumor mass or anatomical difficulty, the tip of the ETT can be placed "in the ballpark" with laryngoscopy, and then advanced under vision through the stylet. Thirdly, in the case of severe soiling or bleeding, the optical/video stylet’s prominent light source can be used as a lightwand, with transillumination at the cricothyroid membrane indicating adequate positioning. A rigid or semirigid optical/video stylet also confers the ability to see the subglottic region, and can be used to advance an ETT under force if needed.

Awake airway management

Where concern over loss of airway patency exists, awake airway management offers an “NPIC” (noli pontes igni consumere, ie, “don’t burn your bridges”) approach, which can safely be modified if the patient is severely uncomfortable. Definitive control of the airway may be achieved by awake tracheal intubation (ATI) or awake tracheostomy (AT). Although commonly used in the past and still popular in resource-limited settings, AT is undesirable where tracheostomy is not needed for postoperative management, and can be very daunting and unpleasant for patients. A less invasive option is awake retrograde intubation, which remains in use in some low-resource areas. However, the improvements and increased availability of endoscopic airway equipment has made ATI the most prominent technique.

Evidence-based expert consensus guidelines for ATI have recently been published and will not be replicated here. However, we wish to highlight specific points. Although the literature suggests that awake VL may be as effective as ATI using a flexible endoscope, use of the nasal approach and/or the risk of a fragile/friable tumor bias our practice towards flexible scopes. Thorough and excellent topicalization of the airway is the single most important principle of ATI. Excellent anesthesia of the airway can be achieved with regional nerve blocks, but this is
Intraoperative care

In our institutional experience, target-controlled infusions (TCI) have a definite role in the management of anesthesia for surgery on upper airway tumors. Total intravenous anesthesia (TIVA) is useful during complex shared airway procedures, as it reduces the risk of awareness during periods that the airway is not secured, and limits contamination of the theatre environment with volatile agents. The ablation of airway reflexes and controlled hypotension may be desirable in specific cases. Typically, TIVA will also be used to maintain anesthesia during jet ventilation.

We routinely use potent opiates by TCI to maintain ideal operative conditions and tightly control both analgesia and sympathetic response. Primarily, two agents are used with very different strategies. Remifentanil offers intense analgesic/sympatholytic effects which are rapidly titratable. It is particularly valuable where control of heart rate and reduction of capillary hemorrhage in the surgical field are desirable, and where the surgical procedure is of limited duration or does not feature significant postoperative pain. Where available, TCI using the Minto model is ideal, but due to the unique pharmacokinetics of remifentanil, a titrated infusion of 0.05-0.40 mcg/kg/min can also be used. However, it is important to recognize the tendency of remifentanil to cause opiate-induced hyperalgesia, and to plan appropriately for postoperative analgesia with this in consideration. We routinely treat with long-acting opiates well prior to discontinuation of remifentanil (for instance, 2-6 mg of titrated intravenous morphine). While the use of NMDA-receptor antagonists such as ketamine are suggested in this context, the unwanted sympathomimetic effects of ketamine discourage this practice. If an NMDA-receptor antagonist or synergistic analgesic is required, magnesium can be used.

For procedures of longer duration (3-4 hours or more), sufentanil TCI using the Gepts model is an ideal intervention. This takes advantage of the context-sensitive half-life of sufentanil to provide a long analgesic “tail” which persists into the postoperative period. As there is always a risk of respiratory depression, the patient should ideally be admitted to a postoperative anesthetic high care unit (PAHCU) when this strategy is employed. (As these patients are usually admitted to a high-care environment in any case, this is of little consequence.) We aim to load the patient with at least 40 mcg of sufentanil before the commencement of surgery, and then run the infusion with an effect-site target of between 0.15 and 0.40 mcg/ml depending on the age and frailty of the patient. We target decrement to between 0.08 and 0.16 mcg/ml by the time the patient is awakened and/or extubated, to allow resumption of spontaneous breathing.

In patients with a diagnosis of obstructive sleep apnoea, other sleep-disordered breathing or where major concern exists for postoperative airway obstruction (in the absence of tracheostomy), opiate-sparing or opiate-free techniques can be used. Patients usually receive balanced analgesia with paracetamol, and a selective COX-2 inhibitor where there is no contraindication. This may be supplemented by low-dose ketamine, lignocaine infusion, or local infiltration. Again, admission to PAHCU is advisable; where facilities do not exist, a reasonable compromise is to use remifentanil intra-operatively and no opiates in the postoperative period.

Emergence

Surgical debulking can convert an obstructive laryngeal cancer into an adequate airway. When significant postoperative airway obstruction is anticipated, a tracheostomy must be considered. It is important to recall that adverse airway events also occur upon extubation. A smooth emergence with spontaneous ventilation in the absence of coughing is always desirable. In this context, the analgesic and antitussive effects of opiates are clearly helpful, with the caveat that respiratory depression, hypercarbia and over-sedation should be assiduously avoided. Analgesia should be multimodal to reduce opiate requirements while still making use of the beneficial effects. When using opiates by TCI, it is useful to maintain a background remifentanil infusion while establishing spontaneous breathing (usually in the range of 0.5-1.0 ng/ml), or aim to have the sufentanil effect-site concentration at the apnoeic threshold (0.16 mcg/ml or less).
nursed with the head of the bed elevated to help reduce neck swelling, as extensive surgery often destroys lymphatic drainage. The administration of warm humidified gas (regardless of the degree of oxygen enrichment) is useful to assist with clearance of secretions, and can easily be achieved via the nasal cannulae, face-mask or tracheostomy with modern equipment. The benefit of warmed, humidified gas with provision of a small amount of PEEP/CPAP may enhance gas exchange in the postoperative setting.

Staff in the postoperative care areas must be trained in the emergency management of complex airways, including protocolized approaches to patients with blocked tracheostomy in the presence and absence of laryngectomy.

**Summary**

Glottic and supraglottic tumors occur frequently and require multidisciplinary care and good communication throughout the perioperative period (Figure 4). Preassessment and special investigations will ideally involve a collaborative approach including the surgeon and anesthesiologist. Focused decisions around the plan for anesthesia and particularly airway management can be aided using point-of-care procedures such as preoperative endoscopic airway assessment and airway ultrasound, especially if there has been delay between diagnosis and operation. PEA may allow patients to be induced and intubated with video laryngoscopy with confidence, but where doubt over ability to maintain the airway or oxygenate after induction of anesthesia still exists, awake tracheal intubation is advisable. Cases in extremis who cannot tolerate ATI may require awake tracheostomy. Balanced anesthesia with excellent postoperative analgesia and admission to the postanesthetic high care unit should be routine.

**Disclosures**

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**References**


