Advanced airway management techniques in anaesthesia for oral cancer surgery: a review

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Abstract: Patients undergoing oral cancer surgery often have multiple predictors of anticipated difficult airway management. Detailed preoperative evaluation of the patient, their medical records and imaging is essential in planning an airway management strategy. Conventional airway management techniques may not reliably achieve tracheal intubation nor rescue oxygenation in situations where tracheal intubation has failed. Postoperatively, the patient's airway may be further compromised due to the presence of airway oedema, blood and bulky reconstructive flaps. Consequently, airway management for major oral cancer surgery presents unique challenges which often necessitate utilisation of advanced airway techniques for both tracheal intubation and extubation. There are several advanced airway management options available to the head and neck anaesthetist and an understanding of the benefits and potential pitfalls of each is crucial. Choice of technique is influenced by the patient, the underlying pathology and its impact upon airway anatomy, the availability of appropriate equipment and local practice, as well as the experience and expertise of the anaesthetist and the multidisciplinary airway team present. Tracheal intubation may be undertaken in the awake patient or the anaesthetised patient and may be performed using a videolaryngoscope, a flexible bronchoscope, a video stylet, a hybrid technique involving multiple devices, or via a tracheostomy. Strategies for postoperative airway management include awake tracheal extubation, exchange of the tracheal tube for a supraglottic airway, use of an airway exchange catheter (AEC), temporary tracheostomy formation or delayed tracheal extubation. Regardless of which technique is being considered, both tracheal intubation and extubation require a multidisciplinary team approach, shared decision-making involving the patient, with discussion of anticipated difficulties, an agreed primary plan and backup plan(s) should the initial plan be unsuccessful.

Keywords: Advanced airway management; intubation; extubation; oral cancer surgery

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Introduction

Background

Squamous cell carcinoma represents the most common form of head and neck cancer (1) and, most frequently arises within the oral cavity (2,3). Surgical management is the primary treatment strategy for oral squamous cell carcinoma and may be combined with adjuvant radiation therapy and/or systemic chemotherapy (1). It is widely established that difficulties with airway management are more likely to be encountered in head and neck patients (4-7). In patients with oral cancer, a multitude of factors can adversely impact upon conventional techniques for airway management such as laryngoscopy, as well as the ability to deliver rescue oxygenation using facemask ventilation and/or insertion of supraglottic airway devices (8,9). Preoperative access to the glottis via the oral route may be compromised due to the site and size of the lesion itself obstructing the oral cavity and preventing insertion of airway devices into the patient's mouth. The sequelae of previous treatment, particularly radiotherapy, may include trismus and reduced mobility of structures such as the tongue and neck due to local fibrosis (8,9). Furthermore, airway anatomy may be unrecognisable due to the presence of the lesion and/or bleeding of necrotic and friable tissues during airway manipulation and instrumentation. Postoperatively, the patient's airway may have further deteriorated due to bulky flap reconstruction occupying a significant volume of the oral cavity, as well as widespread airway oedema and bleeding from extensive surgical handling of tissues (8). Thus, airway management for oral cancer surgery presents unique challenges which may necessitate utilisation of advanced techniques for both tracheal intubation and extubation.

Rationale and knowledge gap

Poor judgement and airway management planning continue to contribute to morbidity and mortality in patients with anticipated difficult airways (4,5,10) and patients undergoing major oral cancer surgery often have predictably difficult airways. Given the heterogeneous impact of the underlying pathology and treatment upon the patient's airway anatomy, a personalised airway management strategy is often necessary. The specific components of such a bespoke airway management strategy will be influenced by the availability of appropriate equipment and the expertise of the anaesthetist and the multidisciplinary team present. Success of such a strategy will depend on having a clear understanding of the clinical scenario as well as the advantages and disadvantages of each technique that is possible. Critically, the anaesthetist must be able to modify their technique as the situation demands.

There has been a proliferation of airway devices and techniques over the last two decades (11) and as a result, the spectrum of options available for airway management has evolved substantially. For example, with the widespread use of supraglottic airway devices, rates of tracheal intubation have decreased (4). Another example is that of awake tracheal intubation (ATI) using flexible bronchoscopy—this has become an uncommon procedure for many anaesthetists (12-15)—perhaps because of increasing experience and familiarity of anaesthetists with videolaryngoscopy in patients who have predicted difficulties with tracheal intubation.

At present, there is no formalised classification to differentiate between conventional and advanced airway management. In the absence of this, the competencies described in the UK Royal College of Anaesthetists' curriculum for anaesthesia for patients with complex airways and the Difficult Airway Society (DAS) guidelines provide a useful framework to consider which techniques may be considered conventional and which may be considered advanced (16,17). Using these documents as a guide, we consider conventional airway management to refer to facemask ventilation, ventilation using a supraglottic airway device or tracheal intubation using direct or videolaryngoscopy in an anaesthetised patient. Advanced airway management techniques include using a videolaryngoscope, a flexible bronchoscope, as well as other innovative strategies to achieve tracheal intubation in either an awake patient or anaesthetised patient. The DAS extubation guideline suggests the following may be considered advanced techniques for postoperative airway management—exchange of the tracheal tube for a supraglottic airway, awake extubation with titrated remifentanil infusion and the use of an airway exchange catheter (AEC) (18).

Objective

For all patients with oral cancer, a robust airway management strategy centred upon maintaining oxygenation throughout the process of performing any airway procedure requires careful consideration and scrutiny of potential failure at each step. There are a number of different advanced airway management options available for tracheal intubation and extubation in patients undergoing oral cancer surgery, and where possible, an evidence-based approach to these techniques is outlined in this review.

Perioperative airway management

Planning tracheal intubation

Detailed preoperative evaluation of the patient and a thorough airway assessment are fundamental in planning airway management—a process which may begin well before the planned surgical procedure. Previous medical records should be scrutinised to determine the relative success and failure of previous airway management strategies. Review of investigations including magnetic resonance or computed tomography imaging of the airway (with 3-dimensional reconstruction and/or virtual 3D endoscopy if available) (19,20) and recent flexible nasendoscopy is strongly advised (4,21-23). By doing this, the anaesthetist should develop a mental image of the anatomical space through which access to the glottis and trachea may be achieved. Furthermore, this understanding of the patient's unique anatomy will allow decisions to be made about the feasibility of certain airway management techniques, ranging from simple facemask ventilation through to advanced techniques (8). Preoperative discussion between the patient, anaesthetist and surgeon is essential. This discussion should include consideration of anticipated difficulties, an agreed primary plan and backup plan(s) and the route of tracheal intubation that will be utilised. There should be clear communication within the team about predetermined endpoints for transitioning from the primary plan to backup options.

Oral cancers can progress rapidly (24,25) thus it is important to consider the date of any prior airway examination, imaging or anaesthetic record that may be used to plan airway management, as the patient's airway may have changed significantly since this date. It is strongly recommended that all elements of the airway assessment are correlated with contemporaneous clinical findings. A repeat flexible nasendoscopic examination on the day of surgery should be considered in patients with rapidly progressive pathology or symptoms affecting airway patency and anatomical relations, to ensure that the chosen airway management strategy is still achievable and safe.

The route of tracheal intubation is influenced by the patient, the nature of the lesion and the proposed surgical procedure. Options for tracheal intubation include nasal, oral, or a tracheostomy. The nasal route is often preferred for patients undergoing oral cancer surgery since this provides unrestricted surgical access to the oral cavity and permits unobstructed continuous review of the aesthetic outcome (26,27). When the nasal route is used, it is important to consider using a nasal vasoconstrictor to minimise the risk of traumatic epistaxis which may make subsequent airway management more challenging (26-29). Submental tracheal intubation is most commonly described in patients undergoing maxillofacial trauma surgery (30,31) and is unusual in patients undergoing treatment for oral cancer, due to the potential risk of fistulae formation.

The type of tracheal tube selected is dependent upon surgical requirements, local practice and the anaesthetist's preference. Common choices include Ring, Adair and Elwyn (RAE) tracheal tubes for nasal intubations and reinforced tracheal tubes which may be used for oral or nasal intubations. RAE tubes maintain a fixed contour similar to the average facial profile thus allowing for oral cavity surgery whilst minimising surgical field interference from bulky connections between the tube and ventilator circuit. However, RAE tubes are associated with an increased risk of bronchial intubation because of their preformed shape (32), so appropriate vigilance should be exercised to ensure optimum placement. With nasal tubes, specific attention should be taken to secure the tube in a position that minimises the risk of pressure injury on the naris. Reinforced tracheal tubes are designed to be flexible and to resist kinking and compression—these properties make them particularly suitable for oral cancer surgery since the tube and circuit can be easily secured and draped away from the operating field. However, an important caution with reinforced tubes is the risk of excessive pressure to the wire-reinforced component causing permanent partial or total occlusion of the internal lumen of the tube (33,34).

For tracheal intubation techniques that rely on railroading of the tracheal tube into the trachea, specific tube characteristics (e.g., material, internal and external diameters, shape, tip design) may minimise the risk of tube impingement at the laryngeal inlet and thus contribute to the success of the technique. For example, the Parker Flex-Tip (Bridgewater, CN, USA) has a curved, centred, tapered and flexible distal tip with a posterior facing bevel. These features are intended to decrease the risk of the tube tip impinging on laryngeal structures during railroading by reducing the size of the gap between the introducer device and the inner wall of the tube compared to a conventional polyvinylchloride tracheal tube (35-38). For similar reasons, using the smallest appropriate internal diameter tracheal tube is also recommended (39,40).

The tracheal tube may be placed in an awake, spontaneously breathing patient prior to induction of general anaesthesia, or in an anaesthetised patient post-induction of general anaesthesia. In recent years, the use of video assisted devices has transformed airway management in patients with anticipated difficult airways (41). Understanding the advantages and potential disadvantages of each device (and associated technique) is essential. The insertion of the tracheal tube may be achieved using a videolaryngoscope, a flexible bronchoscope, a video stylet, a hybrid technique utilising multiple devices, or via a tracheostomy. When difficult airway management is predicted, it is widely accepted that placement of the tracheal tube prior to induction of general anaesthesia (an 'awake tracheal intubation') is the safer option (42).

ATI

The DAS guidelines for ATI in adults provide a useful breakdown of the four key practical aspects of ATI—sedation, topicalisation, oxygenation and performance (42). Whilst a number of potential approaches for each of these practical aspects of ATI exist, the approach described in the guidelines provides a simple, safe and effective method for conducting ATI (42). If minimal sedation is required to improve the patient's tolerance of the ATI procedure, a titrated remifentanil infusion with a target effect site concentration (Minto model) between 1–3 ng/mL is described in the DAS ATI technique. The recommended technique for topicalisation of the airway includes applying co-phenylcaine if using the nasal route and 20–30 sprays of 10% lignocaine to the oropharynx (including targeting sprays specifically at the tonsillar pillars and tongue base). The adequacy of topicalisation should be checked atraumatically and further lignocaine up to a total maximum of 9 mg/kg lean body weight administered if required. ATI may be performed using videolaryngoscopy or flexible bronchoscopy. The guidelines emphasise the importance of ergonomics—the primary operator should have a direct line of sight to the patient monitor, the infusion pumps and the video screen. The patient should be seated in an upright position and secretions should be cleared. The DAS ATI technique recommends the operator is positioned facing the patient for ATI using flexible bronchoscopy whereas for ATI using videolaryngoscopy, the operator should be positioned behind the patient.

High-flow nasal oxygen (HFNO)

Supplemental oxygen should be administered throughout airway management. Heated humidified HFNO is commonly used during the process of tracheal intubation and extubation (43) and may prolong the duration of apnoea without oxygen desaturation during difficult airway management (44). It is well tolerated by awake patients and, in the presence of a patent upper airway, allows a margin of safety should hypoventilation occur. In addition to providing supplemental oxygen, HFNO offers several other physiological benefits including increased alveolar ventilation and reduced work of breathing (43).

The use of HFNO during ATI techniques has additional benefits whilst providing supplemental oxygen. These include improved spread of local anaesthetic during airway topicalisation (45), expansion of the calibre of the airway passages that a flexible bronchoscope may pass through (45), reduced risk of contact bleeding of friable tissues (45), as well as decreased misting of the scope tip.

Preventing unrecognised oesophageal intubation

Abnormal anatomy relating to oral cancer and/or its treatment and the use of advanced airway techniques which involve the railroading of a tracheal tube are risk factors for inadvertent oesophageal intubation. Consensus guidelines to prevent unrecognised oesophageal intubation, produced by the Project for Universal Management of Airways and endorsed by many international airway societies, should be followed (46). At each tracheal intubation or tracheal tube change, sustained exhaled carbon dioxide detection should be used to confirm alveolar ventilation. The absence of this should trigger a series of actions to exclude oesophageal intubation and, in the majority of cases, the tracheal tube should be removed. In situations where tracheal intubation was challenging, there may be hesitation to remove the tube and it should be acknowledged that these same difficulties may also have led to inadvertent oesophageal intubation. Repeat videolaryngoscopy to confirm tube location may not be a feasible option in oral cancer patients. Instead, passing a flexible bronchoscope through the lumen of the tube is likely to be the most appropriate option to establish the site of the tracheal tube. Visualisation of the triad of tracheal rings, trachealis muscle and tip of the tube above the carina should enable confirmation of tracheal intubation. This should be followed by actions to explain and resolve the absence of sustained exhaled carbon dioxide as described in the consensus guideline (46). Oxygenation remains paramount; any actions to investigate and resolve the lack of sustained exhaled carbon dioxide must be prompt, to avoid hypoxaemia.

Videolaryngoscopy

Videolaryngoscopy is increasingly a first-choice technique for tracheal intubation in many clinical situations and offers a better safety profile than direct laryngoscopy (47,48). There is a growing body of evidence supporting the use of videolaryngoscopy in patients with anticipated difficult airways (49,50) and specifically in those with head and neck cancer (51). In patients with oral cancer and in whom mouth opening permits blade insertion, there may be specific advantages to videolaryngoscopy use. Firstly, videolaryngoscopes allow an indirect laryngoscopy technique which does not rely upon alignment of the oral, laryngeal, and pharyngeal axes. This alignment may be impossible with large airway tumours or in the presence of radiotherapy-related fibrosis. Most videolaryngoscopes utilise a camera situated near the blade tip providing a viewing point closer to the glottic opening alongside a more comprehensive visual field than that obtained using direct laryngoscopy. Furthermore, friable tumours susceptible to contact bleeding may cause the airway to deteriorate significantly after airway instrumentation, so techniques such as videolaryngoscopy (47) that are associated with a higher first pass success rate are preferable.

Nasal or oral tracheal intubation is possible using videolaryngoscopy and the procedure is feasible both as an asleep or an awake technique. The choice of videolaryngoscopes is vast and devices can generally be classified as channelled or unchannelled devices, the latter subdivided into those with a Macintosh-shaped blade or a hyperangulated blade. Different techniques are required for the two types of blade shape (48,52). There is some limited evidence that nasal tracheal intubation using a hyperangulated blade may be superior to using a Macintosh blade in patients with oropharyngeal cancer (53,54) but operator experience and expertise with a particular device is key for optimal success rates.

ATI using videolaryngoscopy [awake videolaryngoscopy (AVL)] is associated with a similar success rate to ATI using flexible bronchoscopy (55), including in patients with oropharyngeal cancer (56,57). The technique is clearly dependent on being able to insert the laryngoscope blade into the patient's oral cavity. There is insufficient evidence to recommend one device over another for AVL, and the operator should use the device with which they are most familiar (42). Although limited, there is some evidence that videolaryngoscopy with a hyperangulated blade requires less traction and force applied to airway structures in comparison to a Macintosh blade technique (58), and hence this blade shape may be a better option for AVL.

Whether performed in the awake or anaesthetised patient, documenting how tracheal intubation using videolaryngoscopy was achieved is important. Whilst not widely agreed, a number of different tools are available, including the recently developed Video Classification of Intubation score (59).

Flexible bronchoscopy

Tracheal intubation using flexible bronchoscopy is particularly indicated in patients with large obstructing tumours of the oral cavity and in patients with limited mouth opening. In view of these predictors of airway management difficulty, tracheal intubation using flexible bronchoscopy is more commonly performed as an awake technique (42). In the anaesthetised patient, tracheal intubation using flexible bronchoscopy may be challenging due to relaxation of the pharyngeal tissues causing further restrictions to view and access (60).

ATI using flexible bronchoscopy is commonly performed via the nasal route, and this is often the preferred route in oral cancer patients, to maximise surgical access and to avoid the need for tracheal tube exchange (from oral to nasal) in an anaesthetised patient. Furthermore, it can be difficult to navigate the anatomical landmarks when using the oral route because of the small field of view provided by the tip of a flexible bronchoscope. An oral airway designed to maintain the flexible bronchoscope in a midline position and facilitate navigation over the tongue may be helpful (40). Alternatively, a hybrid technique using an additional device, such as videolaryngoscope, may also assist with passing the flexible bronchoscope over the base of tongue.

Video stylet

Video stylets are wholly or partially rigid tubular devices that allow an indirect view of the glottis on a video screen. Several devices are available, e.g., Bonfils Retromolar Intubation Fiberscope (Karl Storz, Germany), C-MAC Video Stylet (Karl Storz, Germany), and Levitan FPS (Clarus Medical, USA), which all employ a similar principle. Video stylets commonly have an external diameter of 5 mm and may be utilised in situations of reduced mouth opening where a videolaryngoscope would not be able to be passed. The video stylet may be inserted using a retromolar approach or using a midline approach (61). The video stylet, with a preloaded tracheal tube, is inserted into the oral cavity and then manoeuvred to the glottic aperture. At this point, the device may be further advanced through the glottic opening or held at the glottic entrance to enable tracheal tube delivery.

The use of video stylets in ATI has been comprehensively reviewed (61,62), and their use is specifically described in patients with oral cancer and difficult airway management (63,64). Video stylets are associated with a high first pass success rate only when used by operators familiar with the technique and have a comparable risk of complications to other airway devices (62). One small study comparing two experienced operators performing ATI using either a video stylet or a flexible bronchoscope, in patients with an anticipated difficult airway undergoing head and neck surgery, found a high success rate of awake nasal intubation in both groups, but with reduced time to intubation in the video stylet group (65). Thus tracheal intubation using a video stylet in patients with oral cancer may be an option for anaesthetists whose regular clinical practice includes this device.

Hybrid technique

A hybrid technique using more than one device may be considered in complex cases, particularly when the airway anatomy is distorted and the route to the glottis is tortuous. Studies investigating hybrid techniques in difficult airways are limited to case reports (66) and case series (67,68). Most commonly, a hybrid approach involves using a videolaryngoscope with a flexible bronchoscope or a video stylet. The videolaryngoscope provides a wide-angle view of the laryngeal anatomy and facilitates navigation of the flexible bronchoscope or video stylet (with their narrow fields of view) acting as a steerable introducer to the glottic opening. This may allow placement of the tracheal tube from both above and below the vocal cords to be observed.

Retrograde tracheal intubation

Retrograde tracheal intubation is usually a technique that is reserved for patients whose upper airway anatomy is extremely distorted and standard anatomical landmarks are unrecognisable. There are multiple published descriptions of how to perform a retrograde tracheal intubation and these are summarised elsewhere (69). The basic steps of the technique include: initial identification of the cricothyroid membrane, which can be aided by ultrasound scanning, particularly when anatomical landmarks are not easily palpable (70); needle puncture of the cricothyroid membrane, to allow passage of a retrograde guidewire; advancement of the guidewire in a cephalad direction until it emerges from the upper airway; delivery of the tracheal tube into the trachea, which can be facilitated by using a variety of techniques, including using an AEC or passing the guidewire through the distal end of the working channel of a flexible bronchoscope, or utilisation of the guidewire as a visual guide to the laryngeal inlet. Complications associated with the technique are usually minor (69).

Tracheostomy

An awake tracheostomy may be indicated as the primary or secondary airway management plan in patients with significant airway pathology, in whom the chances of successful ATI are deemed to be low. Reports in the literature of awake tracheostomy as an airway strategy in patients undergoing oral cancer surgery when other techniques are not feasible or have failed are scarce. In general, the favoured technique in this situation is a surgical tracheostomy however a percutaneous tracheostomy may be used depending on the personal preference of the surgeon. This is likely to be a high-risk procedure and the patient should be counselled appropriately.

Ultrasound scanning may aid landmark identification of the proposed tracheostomy site as well as any overlying blood vessels (71). Awake tracheostomy should be performed following local anaesthetic infiltration. If local anaesthetic has been used for a recent failed ATI attempt, this should be factored into the local anaesthetic toxic dose calculation. HFNO can be used during the tracheostomy procedure to try to maintain oxygenation. It is important for the theatre team to remain vigilant to the risk of fire when using surgical diathermy in the presence of HFNO and minimise this risk where possible (72). Whilst sedation is not essential (and may not be recommended), judicious administration can often help improve the patient's tolerance of the procedure. The use of a variety of sedative agents has been described in case reports and case series (73-77). In keeping with the DAS guidance for minimal sedation in ATI, a target controlled infusion of remifentanil can be very effective in this context, especially when combined with a team member specifically allocated to maintaining verbal contact and providing reassurance to the patient throughout the procedure.

Management of loss of airway during an awake tracheostomy procedure depends upon the specific circumstances. Utilising the principles outlined in recommendations from multidisciplinary guidelines for the management of tracheostomy emergencies (78) and the DAS Plan D guidelines (17), attempts to maintain oxygenation may require simultaneous and separate efforts directed at administering oxygen via the upper airway whilst establishing an emergency front of neck airway.

Choice of tracheal intubation technique

There are a number of options available to achieve tracheal

Table 1 Comparison of advanced airway techniques for tracheal intubation

Variables	Video-laryngoscopy	Flexible bronchoscopy	Video stylet	Retrograde	Surgical tracheostomy	Emergency front of neck airway
Complexity of procedure	Low	Moderate	Moderate	Moderate–high	Moderate–high	Low–moderate
Number of procedures to achieve basic competence to perform procedure when no airway difficulty is predicted[†]	1–6	>25	~20	No data	10	>5
Equipment setup[††]	Fast	Fast	Fast	Moderate	Slow	Fast
Field of view[††]	Broad	Narrow	Narrow	Narrow	Specific to incision	Specific to incision
View of tracheal intubation[††]	Glottic	Tracheal	Tracheal	Tracheal	Anterior neck/ tracheal	Anterior neck/ tracheal
	Hybrid technique—usually glottic and tracheal					
Affected by secretions and/or blood[††]	Moderate	Severe	Severe	Variable	Moderate	Minimal
Intubation time[†††]	<<1 minute	>1 minute	<1 minute	Minutes	Minutes	<1 minute
References	(52,79-81)	(79,80)	(61,62)	(69)	(82)	(83,84)

[†], for many anaesthetic procedures, there is a steep learning curve for the first 30 cases and the learning curve does not flatten off beyond at least 100 cases (85); [††], data provided based on first principles; [†††], excludes time taken for any local anaesthetic topicalisation of the airway.

intubation and each clinical situation requires a bespoke multidisciplinary airway management strategy. *Table 1* (52,61,62,69,79-85) provides a summary of the main options for tracheal intubation in patients undergoing oral cancer surgery and summarises some of the factors that may influence choosing one technique over another. Published literature in this area is of generally low-quality since it is not straightforward to compare one technique to another. The decision to proceed with a specific technique will be primarily guided by the patient, their unique airway anatomy, the availability of appropriate equipment as well as the skillset of the multidisciplinary airway team present (4). Local culture and practice heavily influence choice of technique and consequently there may be institutional variation in management of similar cases (86). Other considerations relating to equipment include the ease of use, speed of setup and the type of view that will be obtained. The learning curve and skill acquisition associated with the use of any technique or device is affected by many factors (87). Some techniques, whilst novel, are easy to learn and perform because they are based on using existing and established cognitive and manual dexterity skills (e.g., AVL) (88). This is in contrast to techniques which rely upon unique device handling or viewing anatomy from a different perspective (e.g., flexible bronchoscopy or video stylet). Such techniques may not be used frequently, and thus are likely to be associated with slower achievement of proficiency combined with rapid skill attrition (15,89). Regular simulation and workshop training to practice, maintain and improve airway management skills for these less regularly used techniques are likely to be crucial to successful performance when needed (15,89,90).

Postoperative airway management

Postoperative airway assessment and planning

Patients who have undergone oral cancer surgery may have significant airway compromise in the immediate postoperative period due to the presence of blood, oedema and bulky reconstructive flaps. The DAS extubation guideline provides a useful structure that can be followed for this stage of airway management (18). A multidisciplinary approach to the formulation of a postoperative airway strategy is essential. A risk assessment should be undertaken which includes discussion of anticipated difficulties, an agreed primary plan and backup plan(s). The surgical team should remain in the operating theatre until the patient's airway is deemed safe. Postoperative planning should take into consideration the potential for delayed airway compromise, with a clear airway management strategy established along with ensuring the availability of a skilled team to manage airway rescue. There is likely to be considerable variation between institutions and between daytime and out-of-hours provision of airway rescue services—this must be factored into the risk assessment. A number of head and neck surgical centres have established multidisciplinary difficult airway rescue teams that operate day and night to meet this clinical need (91).

Strategies for tracheal extubation include awake tracheal extubation (with or without HFNO and with or without pharmacological assistance), exchange of the tracheal tube for a supraglottic airway, and use of an AEC. For high-risk situations, a temporary tracheostomy may also be performed. Alternatively, it may be appropriate to delay tracheal extubation for 24–48 hours to allow airway oedema to subside.

Awake tracheal extubation

The patient's physiological ability to undergo a trial of tracheal extubation should be optimised. This includes ensuring that the patient is preoxygenated and the presence of any residual neuromuscular blockade has been quantitatively assessed and appropriately reversed where necessary. HFNO should be considered as part of the tracheal extubation strategy for high-risk patients.

Prior to tracheal extubation, and whilst the patient is still deeply anaesthetised, the oropharynx should be meticulously inspected and suctioned under vision. During this assessment, the anaesthetist should ensure that any packs, swabs, or blood clots are removed from the airway. This should involve manipulation of the head and neck to dislodge any concealed clots in the nasopharynx as well as suctioning behind the soft palate and in the supraglottic region.

An awake extubation strategy is often the safest technique in high-risk patients, and it is desirable to minimise the risk of coughing, agitation and haemodynamic perturbations at the time of tracheal extubation. Several pharmacological options are available to facilitate smooth emergence and tracheal extubation (92). Continuous infusions of remifentanil or dexmedetomidine may be used to facilitate patient tolerance of the tracheal tube whilst consciousness returns and adequate spontaneous ventilation resumes.

The DAS extubation guideline supports the use of titrated remifentanil infusions during the process of awake tracheal extubation in 'at risk' patients and suggests a sequence of steps that can be followed (18). The optimal dose of remifentanil that reliably allows smooth tracheal extubation without delayed emergence and apnoea remains unknown, with a wide range of doses suggested. One small study found a remifentanil target-controlled infusion effect site concentration of 1.5 ng/mL facilitated smooth awake tracheal extubation in patients undergoing endoscopic sinus surgery (93). There is emerging evidence that a dexmedetomidine infusion may be a useful alternative in achieving smooth emergence and awake tracheal extubation (94,95). Further research is needed to elucidate the optimal pharmacological agent and the ideal dose range needed to safely assist a smooth awake tracheal extubation in patients who have undergone complex head and neck surgery.

Tracheal tube exchange to a supraglottic airway device

It may be appropriate to consider exchange of the tracheal tube to a supraglottic airway device. This technique offers the advantage of a smoother emergence with a reduced risk of coughing compared to awake removal of a tracheal tube, and is potentially safer than undertaking a deep extubation technique (18). Well-positioned supraglottic airway devices maintain the airway, reduce the volume of blood and secretions entering the larynx and allow assessment of the adequacy of spontaneous ventilation. However, the presence of bulky reconstructive flaps within the oral cavity and airway oedema may preclude the use of this technique.

The original description of the technique is known as the Bailey manoeuvre (96) and involves the placement of a Classic Laryngeal Mask Airway (LMA-Classic™, Intavent Orthofix, Maidenhead, UK) behind the tracheal tube, followed by inflation of the laryngeal mask airway cuff and deflation of the tracheal tube cuff, with subsequent removal of the tracheal tube. The technique for airway substitution with a LMA is described in the DAS extubation guideline (18). It is important that the technique is performed after inspection and suctioning of the airway whilst the patient is deeply anaesthetised.

Whilst there is limited evidence to support the use of one specific supraglottic airway device over another for airway substitution, some small studies have shown relatively positive results for the use of the I-gel™ (Intersurgical Ltd., Wokingham, Berkshire, UK) (97), the Proseal™ (PLMA, LMA North America, San Diego, CA, USA) (97) and the Ambu® LMA (Ambu A/S, Ballerup, Denmark) (98) in this situation. However, there are no studies examining the technique or comparing devices specifically in patients who have undergone oral cancer surgery.

AECs

An AEC is a long, thin, hollow flexible tube with centimetre depth markings. AECs may be used as a conduit to the trachea after tracheal extubation to facilitate airway rescue and to aid reintubation in the postoperative period (when this is anticipated to be challenging). An AEC can be placed orally or nasally, and emergency tracheal intubation can be achieved via either route by railroading over the *in situ* AEC (99).

Whilst AECs are available in a number of different outer diameter sizes and lengths, the most suitable to facilitate AEC-assisted tracheal extubation are the 11 and 14 Fr devices (18,100). The 11 and 14 Fr AECs have an external diameter of 3.7 and 4.7 mm respectively, and thus are of sufficiently small calibre to be tolerated by most awake patients (100). The ideal length of an AEC should be no greater than twice the length of the tracheal tube that is being used—this generally equates to approximately 56 cm (101), however, the typical length of commonly available AECs is 83 cm (Cook Medical, USA).

Immediately prior to undertaking tracheal extubation in an 'at risk' patient, the AEC should be inserted through the lumen of the *in situ* tracheal tube. The depth markings on the tracheal tube and the AEC should correspond indicating that the distal tips of both devices are aligned. The maximum recommended depth of insertion of an oral AEC is 25 cm (18) and the specific depth for each individual patient should be noted. There are no agreed equivalent recommendations for the depth of a nasally inserted AEC. A study examining 124 patients with nasal AECs *in situ* found an average insertion depth of 29 cm (99). Meticulous care should be taken to ensure that the distal tip of the AEC lies in the mid-trachea and is not positioned at or beyond the carina, since this carries the risks of airway stimulation and trauma. The DAS extubation guideline outlines the sequence of steps that should be undertaken when performing tracheal extubation with an AEC *in situ* (18).

A correctly positioned AEC is usually well tolerated by patients without any local anaesthesia or sedation. There is some evidence that a nasally inserted AEC is associated with reduced rates of coughing and retching compared to an oral AEC (99). The patient should be able to talk and cough without difficulty or discomfort. Supplemental oxygen can be administered via a simple facemask or HFNO. Many AECs can be connected to an oxygen supply through a connector that enables oxygen insufflation. However, even low oxygen flow rates (1–2 L/min) can result in significant barotrauma, and thus supplemental oxygen should not be administered via an AEC except in situations of life-threatening hypoxaemia (102).

The patient should be nursed in a monitored postoperative environment with staff familiar with airway observation and AECs. The AEC should be removed when the patient and their airway is deemed safe and stable. The patient should remain nil by mouth until this point. A stable airway is usually anticipated to be achieved within several hours of tracheal extubation (99,100), but an AEC may be tolerated for up to 72 hours (100).

Postoperative emergency reintubation over an *in situ* AEC is an uncommon scenario and studies examining success rates of this technique include only relatively small numbers of patients (99,100,103). The rate of failure to reintubate using the AEC in this situation may be as high as 22% (103). Inadvertent displacement of AECs (or equivalent devices) in the postoperative period ranges from 4% to 11% of patients (99,104,105). Waveform capnography is an unreliable method to confirm tracheal placement of an AEC and, if necessary, AEC location should be confirmed using flexible nasendoscopy (99).

In situations where there is an AEC in place and the patient requires tracheal intubation, standard precautions and preparation for anticipated difficulty should be made. An awake or asleep tracheal intubation technique may be utilised and depending on technique, the AEC may be used as a conduit for the tracheal tube insertion or simply as a visual guide to the laryngeal inlet. If the AEC is used, the previously noted depth of insertion can provide a guide to tracheal tube depth. Tracheal tube placement should be confirmed by the presence of sustained exhaled carbon dioxide on capnography.

Difficulty railroading the tracheal tube over the AEC may be encountered at the laryngeal inlet where the difference in size between the small calibre AEC and the larger internal diameter of the tracheal tube may cause the tracheal tube to catch on glottic structures. An Aintree Intubation Catheter (AIC) (Cook Medical, USA) is a semi-rigid tube 56 cm in length, with an internal and an external diameter of 4.7 and 6.5 mm respectively. These dimensions make the AIC a useful device to close the gap between the AEC and the tracheal tube. Railroading a 7.0 mm internal diameter (or larger) tracheal tube over the AEC-AIC combination may reduce the risk of the tracheal tube catching on glottic structures and thus increases the chance of successful reintubation using this technique (106,107).

The Cook Staged Extubation Set (Cook Medical, USA) comprises equipment for undertaking tracheal extubation via a modified AEC-extubation technique, and its use has been described specifically in patients following head and neck surgery (108). A flexible-tipped wire, as opposed to a catheter, is left in the trachea following tracheal extubation. In the event that the patient requires reintubation, a soft tapered catheter is passed over the wire first, and then the steps described above can be undertaken.

Temporary tracheostomy

Elective temporary tracheostomy is a common and well-established postoperative airway strategy in major head and neck oncological surgery. The decision to perform a tracheostomy in this group of patients is not made lightly due to the attendant risks of significant morbidity, with reported complication rates ranging between 2% and 45% (109-115). Pneumonia is a common postoperative complication in patients who have undergone major head and neck surgery, with tracheostomy recognised as a risk factor (111,115-118).

In view of this, there is considerable variation in practice between head and neck surgical centres (119). A number of scoring systems have been proposed to identify patients in whom tracheostomy would be the safest postoperative airway strategy (120-125), and at present, no particular tool has demonstrated superiority. Purported limitations of these existing scoring systems include the potential for overprediction of tracheostomy requirement (126-128) and inconsistency in predicted outcome achieved with different scoring systems applied to the same patient (127,128). A recent evaluation of factors contributing to delays in decannulation following temporary tracheostomy in patients who had undergone free tissue reconstructive surgery for head and neck cancer found that a fifth of patients underwent decannulation after one to two days, which raises the question of whether a temporary tracheostomy had been indicated at all (129).

Thus, it remains that the decision to perform a temporary tracheostomy to facilitate postoperative airway management should be made on a case-by-case basis by the multidisciplinary team. The decision should be influenced by anticipated postoperative airway compromise from oedema, bleeding and potential subsequent difficulties with airway rescue, amongst other factors.

There are no widely accepted recommendations for sizing of tracheostomy tubes (130). However, appropriate sizing is important to minimise the risk of inadequate ventilation, tube dislodgement, cuff leaks, and bleeding. Tracheostomy tube choice is influenced by a number of factors including gender, body habitus, existing tracheal tube size, and a need for the distal tip of the tube to be positioned 2–4 cm proximal to the carina. If available, existing computed tomography imaging of the thorax may be used to help select the appropriate size of tracheostomy tube (131).

Patients with a temporary tracheostomy should have bed-head signs displayed to allow essential information about their airway to be immediately available in the event of an airway emergency. Details should include which team(s) should be rapidly mobilised and whether there are any special considerations for managing the patient's airway (4,78).

Delayed tracheal extubation

Delayed tracheal extubation may be an alternative to temporary tracheostomy formation in selected patients who have undergone major oral cancer surgery. Similarly, the decision for delayed tracheal extubation should be made on a case-by-case basis by the multidisciplinary team. In the absence of a widely accepted and validated scoring systems to guide whether a patient should have a delayed tracheal extubation or not, the decision will be based on clinical judgment and institutional norms. A delayed extubation approach may potentially impact upon intensive care unit (ICU) bed capacity in certain institutions, where postoperative patients with a tracheostomy may routinely be managed in other monitored clinical areas but would mandate ICU admission if they remained intubated overnight. Case series which describe local experience of delayed tracheal extubation in patients who have undergone major oral surgery suggest that delayed tracheal extubation may be a safe option for postoperative airway management and that temporary tracheostomies may be unnecessary in some patients (112,126,127). At present, there is insufficient evidence to predict the specific characteristics of patients who will fail a trial of delayed tracheal extubation and whose primary postoperative airway management plan should be a temporary tracheostomy.

Patients who are admitted to ICU for delayed tracheal extubation should have a clearly documented airway management strategy in case of accidental tracheal extubation (4). It is vital to clearly identify these patients as those in whom airway management is known or anticipated to be difficult—the use of high visibility bedhead signs is recommended to serve as a trigger to rapidly mobilise the relevant team(s) and to indicate patient specific recommendations for airway management in the event of accidental tracheal tube displacement (4,132).

Delayed extubation on ICU should take place following the same level of planning and preparation, with all the appropriate personnel and equipment, as recommended for any other high-risk tracheal extubation procedure. Indeed, tracheal extubation of these patients should follow the same principles outlined for the safe tracheal extubation of all ICU patients with predicted airway management difficulty (133).

Conclusions

Patients with oral cancer have predictably difficult airways and often require the utilisation of advanced airway management techniques for both tracheal intubation and extubation. This review highlights the wide range of potential advanced airway techniques in the armamentarium of the head and neck anaesthetist. At present, there is often insufficient high-quality evidence to recommend one particular technique over another. Much of the published literature in this area consists of case reports and case series—this is unsurprising since patients undergoing oral cancer surgery are a heterogenous group and airway management can be successfully performed using a variety of techniques. Choice of technique is influenced by the patient and their unique airway, the availability of appropriate equipment, the experience and expertise of the multidisciplinary team present as well as institutional norms. Whichever strategy is adopted, successful airway management requires careful planning and a collaborative approach. Anticipated difficulties, an agreed primary plan and triggers to initiate backup plan(s) should be discussed in advance of undertaking any advanced airway procedure. Maintaining oxygenation throughout performance of these procedures is crucial. From the moment a tracheal tube is inserted until tracheal extubation, continuous capnography is mandatory. The learning curve and skill acquisition associated with the use of any advanced airway procedure or device is varied, and is affected by several factors including how frequently the technique is performed. Thus, regular simulation and workshop training to practice, maintain and improve both technical and non-technical airway management skills for these less regularly used techniques is vital to increase the chances of success when they are needed.

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