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Airway management of tracheal tumours

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INTRODUCTION

Tracheal tumours, although rare, pose significant challenges to anaesthetic management due to their potential to compromise airway patency and ventilation. These tumours originate in the tissues of the trachea and can obstruct the airway to varying degrees depending on their size, location, and growth pattern. Their rarity means most anaesthetists may only encounter them infrequently, typically only in tertiary centres. Despite this, a sound understanding of their implications and the strategies available for their management is essential.

This narrative review aims to provide anaesthetists with a practical and clinically focused overview of tracheal tumours, exploring their clinical presentation, relevant pathophysiology and classification systems. Anaesthetic implications, detailed strategies for airway assessment and management will be discussed. The goal is to support informed decision-making in both elective and emergency settings.

CLINICAL PRESENTATION

Symptoms of tracheal tumours are often insidious and non-specific. They typically relate to the mass effect of the tumour and may mimic more common respiratory conditions such as asthma or chronic obstructive pulmonary disease.[1] Due to the trachea's considerable diameter, symptoms may only appear after significant tumour growth – typically at 50 to 70 per cent of luminal narrowing.[1] Dyspnoea is the most common presenting symptom seen on exertion (tracheal lumen narrowing less than 8 mm) and at rest (tracheal lumen narrowing less than 5 mm).[2] Cough is common, which may be persistent and non-productive.[3] Stridor, a respiratory sound caused by turbulent airflow through a partially obstructed airway, occurs later in tumour progression. Stridor can be inspiratory, expiratory, or biphasic, depending on the level of airway obstruction. Inspiratory stridor occurs with obstruction of the extrathoracic trachea, expiratory stridor when only the intrathoracic trachea is involved and biphasic stridor when the obstruction is at the level of the glottis or subglottis. Haemoptysis, due to mucosal irritation, may be present, and some patients may rarely complain of hoarseness if the tumour affects the vocal cords or the recurrent laryngeal nerve.[1] The subtlety of symptoms often leads to diagnostic delays, resulting in more advanced disease at presentation and more complex surgical and anaesthetic management.

CLASSIFICATION OF TRACHEAL TUMOURS

Tracheal tumours can be classified by histology, anatomical location, friability, and their mechanical effect on airflow. Each of these classifications carries important implications for anaesthetic planning.

Histology

Histologically, tracheal tumours may be malignant or benign (see Table 1). Primary neoplasm is rare, accounting for 0.1–0.4 per cent of all malignancies worldwide.[4] Patients may be older with associated risk factors, including smoking and alcohol use, while in younger patients, human papillomavirus exposure might be the cause of cancer development.[5] Distant metastases are rare (around 10 per cent at the time of diagnosis) and most commonly are found in the patient's lungs.[4] The majority of cancers are secondary tumours, which occur due to the invasion of the trachea from cancers located in surrounding structures, including the larynx, lungs, oesophagus and thyroid glands.[4] The airway management implications for secondary tumours may be similar to the primary neoplasms, though patients will likely require more complex surgical treatments.

The most common malignant tumours include squamous cell carcinoma and adenoid cystic carcinoma (see Table 2). Less common malignant types include mucoepidermoid carcinoma, carcinoid tumours, and sarcomas.[2,6] Benign tumours, such as papillomas, hamartomas, and chondromas are typically managed surgically and have a more favourable prognosis.[6] Secondary tumours, which invade the trachea from adjacent structures such as the oesophagus, lung, or thyroid, are more prevalent overall and often present with more complex multidisciplinary team (MDT) requirements.[6]

Table 1. Breakdown of tumour type by prevalence and histology

	More Common	Less Common
Malignant	Squamous cell carcinoma (50–75%) Adenoid Cystic (10–15%)	Mucoepidermoid carcinoma Carcinoid tumour Sarcoma Primary tracheobronchial lymphoma Inflammatory myofibroblastic tumour
Benign	Papilloma	Hamartoma Chondroma Lipoma Amyloidoma Leiomyoma Neurogenic tumour Salivary gland tumour

Table 2. Comparison between the most common primary malignancies

	Demographics	Disease Progression	Usual time to diagnosis	Options
Squamous cell carcinoma	60–70 years Male > Female Smoker	Poorly differentiated Rapid growth Early metastases and regional spread	4–6 months after symptom onset	Less amenable to tracheal resection
Adenoid cystic carcinoma	40–50 years Male = Female Non-smoker	Well differentiated Slow growth Mass effect > regional invasion	>1 year after symptom onset	More amenable to tracheal resection

Differentiation between malignant and benign tumours is important as it affects decision-making regarding the timing of surgery, type of surgery and treatment modalities. As malignant tumours require more urgent surgery, there will be less time for patient optimisation and prehabilitation. Surgical resection provides improved patient outcomes, especially for benign and low-grade malignant tumours.[7] Tracheal tumours are considered resectable if the involved segment can be resected and reconstructed with primary anastomosis.[2]

Malignant lesions may initially be managed with neoadjuvant chemotherapy alone, as radiotherapy may negatively impact the healing of a resection. Patients unsuitable for surgical resections may be offered alternative treatments, including radiation therapy and interventional bronchoscopy.[7]

Anatomical location

In addition to the size of the lesion, the anatomical location also significantly influences management (see Figure 1). Tumour location can be defined as in the subglottic region (upper third), proper trachea region (middle third), and the carina region (lower third). Tumours located in the upper third may be amenable to tracheostomy or intubation using advanced airway management techniques. In contrast, tumours in the middle or lower thirds (thoracic) pose greater challenges for airway management due to restricted access and limited airway options.

It may be more appropriate for the anaesthetist to visualise the tumour's location as intrathoracic (thoracic trachea) or extrathoracic (cervical trachea), as this will have the most significant impact on airway strategy from an anaesthetic and surgical viewpoint. Intrathoracic lesions occur from the level of the second thoracic vertebra within the thoracic cavity.

Tracheal lumen narrowing is due to tumour growth from the lumen wall (primary or secondary invasion) or narrowing of the gap lumen by extraluminal tumour (secondary tumours).[2]

Airway obstruction can be classified based on the origin and location of the tumour (see Figure 2):[2]

- Endoluminal – located inside the lumen.
- Extraluminal – tissues external to the trachea, causing mass effect.
- Extraluminal with endoluminal extension.

Mechanistically, tumours may create a ball-valve effect – allowing air entry during inspiration but restricting expiration, leading to gas trapping and dynamic hyperinflation. Alternatively, a "cork in a bottle" phenomenon can occur when instrumentation dislodges or compresses a partially occluding tumour, resulting in complete obstruction.

Figure 1. Anatomical division of the trachea

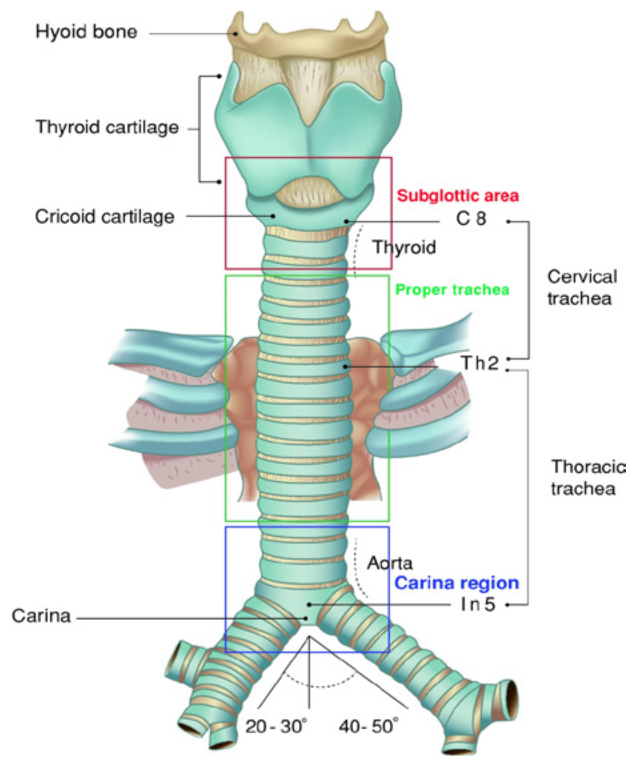
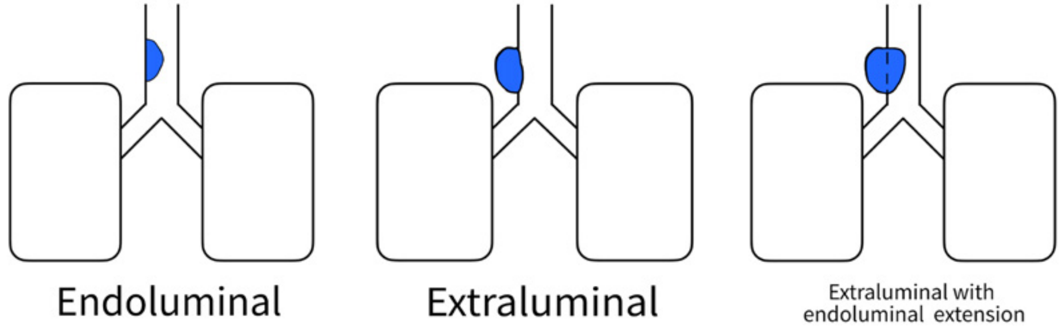


Image sourced from Dorn and Kocher (2020).[8]

Figure 2. Airway obstruction classification by tumour location and origin



Bleeding potential

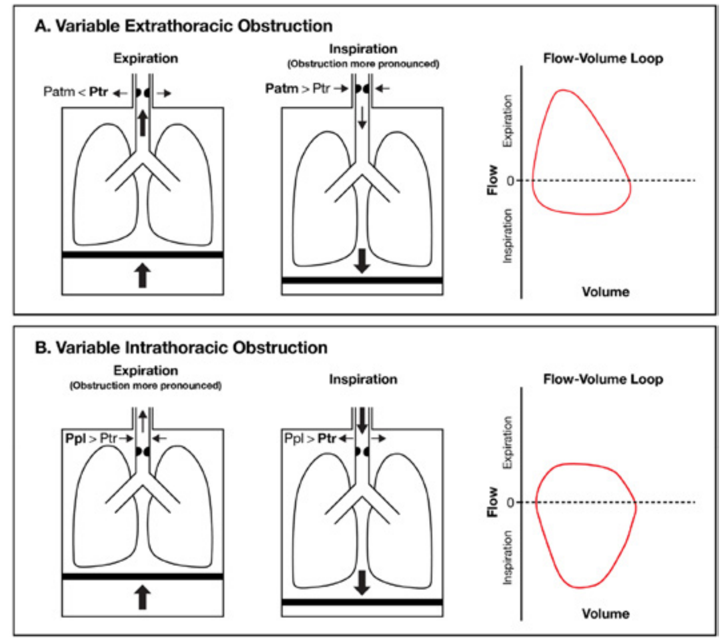
Tumour friability and bleeding potential are critical to airway instrumentation. Friable tumours may bleed with minimal contact, complicating flexible bronchoscopy or other visual-guided techniques. Ongoing anticoagulation therapy, coagulopathy, or malignant histology can further increase this risk.

ASSESSMENT AND IMAGING

A thorough airway assessment is fundamental to effective planning. While history, physical examination, and review of prior anaesthetic records are essential, imaging and endoscopic evaluations provide the most accurate anatomical detail. Tumour progression can result in significant changes within a short timeframe. When signs or symptoms are not consistent with findings on previous records or images, the value of repeating scans should be considered.

Chest X-rays are often the first investigation in non-specific symptomatic patients. Findings are usually non-diagnostic, have low sensitivity, and the entire length of the trachea might not be captured.[9] Computed tomography (CT) of the neck and chest is the modality of choice, offering high-resolution, multiplanar views of the lesion's extent, degree of obstruction and proximity to the carina and surrounding structures.[9,10] Ultrasound, as part of a bedside review of the patient by the anaesthetist, may assist in identifying surface landmarks and planning for front of neck access (FONA).[12] Bronchoscopy offers a real-time assessment of tumour friability, intraluminal position, and bypass potential, though it carries risks in highly vascular or obstructive lesions.[11] Biopsies can be taken, which can guide histological diagnosis.[2] Virtual bronchoscopy derived from CT scans may be a valuable option when conventional bronchoscopy is contraindicated.[9] There is little evidence in the literature regarding pulmonary function tests, and they are only recommended for their usual indications. Notably, flow-volume loops (see Figure 3) may reflect typical patterns of obstruction based on lesion characteristics and location.[2]

Figure 3. Influence of location of obstructing tumour on flow-volume loop



a) Variable Extrathoracic Obstruction: Maximal airflow limitation occurs during inspiration when the combination of positive atmospheric pressure and negative intraluminal pressure reduces the extrathoracic airway diameter, thereby increasing resistance to airflow due to the obstruction;

b) Variable Intrathoracic Obstruction: Maximal airflow limitation occurs during expiration when pleural pressure becomes positive relative to intraluminal airway pressure, reducing the diameter of the intrathoracic airways and making any obstruction more pronounced. Image sourced from Amaza et al. (2018).[13]

AIRWAY MANAGEMENT STRATEGIES

Airway management in patients with tracheal tumours must be adapted to individual patient and tumour characteristics. A thorough preoperative discussion with the surgical and critical care teams is vital. Anaesthetic backup plans should be developed and communicated clearly to all team members.

High-flow nasal oxygenation

High-flow nasal oxygenation (HFNO) may be helpful in maintaining spontaneous ventilation during short procedures or as a bridge technique. It may be used as an apnoeic oxygenation technique but can also be used as a spontaneous ventilation technique, thereby avoiding the need for neuromuscular blockade and preserving airway tone. However, HFNO requires a patent airway at all times, does not protect against aspiration, and is unsuitable for lengthy procedures that may require controlled ventilation.[14] Concerns have been raised regarding the spread of viral particles in the case of HSV-associated papilloma.

Jet ventilation

Jet ventilation delivers oxygen via a jet stream originating from a high-pressure source. There are options for low-frequency and high-frequency jet ventilation. While effective in maintaining a tubeless field, it requires specialised equipment and expertise. It carries risks, including barotrauma, impaired CO_2 clearance, and aspiration.[15,16] With the advent of HFNO and improved supraglottic devices, jet ventilation has become less mainstream.

Heliox

Heliox (a mixture of helium and oxygen gas) confers a theoretical advantage in the management of airway obstruction as a low-density gas that lowers Reynolds number and decreases turbulent flow. It has limited utility in modern-day anaesthetic practice as it requires specialised cylinders, calibration of ventilators for use, and does not allow for higher fractions of oxygen delivery, risking hypoxia. There is no mention of its use in any recent literature around tracheal tumour airway management.[17]

Supraglottic airway

Supraglottic airways (SGA), especially second-generation models, allow for oxygenation and flexible bronchoscopy access while minimising airway manipulation. Spontaneous ventilation can be achieved as muscle relaxation is not required. This minimises the loss of muscle tone while under general anaesthesia.[16] Second-generation devices are more suited to complex airway surgery, given features like improved cuff design, a gastric port and incorporated bite block.[16] Flexible bronchoscopes can be passed down the lumen of an SGA, allowing for surgical access while maintaining an airway. We note the internal diameter of an IGEL 5 (13 mm) compared to a size 8.5 endotracheal tube (8.5 mm).[16] SGAs are limited by bleeding risk, the potential for laryngospasm, risk of aspiration, airway contamination due to bleeding, and the concern of not providing a definitive airway.[16]

Endotracheal intubation

Endotracheal intubation may not only be challenging in patients with tracheal tumours but also, depending on cancer location, the endotracheal tube (ETT) may impede surgical access in cases of high lesions, and may not be able to overcome obstruction in cases of low-lying tumours. ETT selection is important, considering the advantages and disadvantages of microlaryngoscopy tubes, reinforced tubes and laser-safe ETTs.[16] Sizing of endotracheal tubes must consider the actual outer diameter, noting that ETTs are named for their internal diameter (see Table 3). For laser-safe tubes, the outer diameter is likely to be larger than conventional ETTs due to the presence of additional insulation layers.

Table 3. Conventional endotracheal tube sizing by internal and outer diameter

PVC ETT	Internal diameter (mm)	Outer diameter (mm)
#5.0	5.0	6.7
#5.5	5.5	7.3
#6.0	6.0	8.0
#6.5	6.5	8.5
#7.0	7.0	9.2
#7.5	7.5	10
#8.0	8.0	10.7
#8.5	8.5	11.3
#9.0	9.0	12.2

Crossfield intubation

Crossfield intubation, where the surgical team places a sterile ETT through the surgical field following tracheal transection, offers excellent airway security without compromising surgical access.[18] This technique requires strict suppression of cough reflexes and clear communication between surgeons and anaesthetists. The ETT must be transitioned to another method prior to extubation.[18]

Rigid bronchoscopy

Rigid bronchoscopy has not been extensively described in the anaesthetic literature for elective indications, but it may be a technique of choice for the surgeon. Patients require deep muscle relaxation and a good range of motion of the cervical spine to allow for appropriate neck extension. Depending on the type of scope used, passive oxygenation via the rigid bronchoscope is possible, with consideration for the risks of barotrauma and pneumotrauma.[16] It may be utilised for the process of tumour debulking within the trachea as part of a multi-step approach to the management of the tumour.

Awake flexible bronchoscopy

Awake flexible bronchoscopy (traditionally referred to as awake fibre-optic intubation) allows for guided placement of an endotracheal tube past the tumour.[16] It requires expertise to topicalise and guide the tube, and may cause bleeding in friable tissue. Concerns about the narrowing of the tracheal lumen leading to a “cork in the bottle” phenomenon may preclude its use in a range of patients.[19] The diameter of the scope and its ability to fit the internal diameter of the required endotracheal tube may play a role in decision-making (see Table 4). Case reports describe the use of ketamine, dexmedetomidine, remifentanil or low-dose propofol for anxiolysis.[16] Great care must be taken in ensuring that respiratory drive and muscle tone are not affected when using sedation medications.

Table 4. Examples of flexible bronchoscopy sizing (Ambu ascope) with endotracheal use

Ambu ascope brand	Flexible bronchoscope outer diameter (mm)	Smallest ETT that can be passed over scope	Smallest ETT outer diameter (mm)
Slim	3.8	#5.0	6.7
Regular	5.0	#5.5	7.3
Large	5.8	#6.0	8.0

Awake tracheostomy

Awake tracheostomy can provide a secure airway without the need for general anaesthesia. This technique requires patient cooperation and excellent neck extension and carries its risks, including bleeding and airway soiling.[19] The location of the tumour dictates the viability of this technique, as the tracheostomy must be placed below the tumour. Hence, tracheostomy is not appropriate in lower tumours closer to the carina.

Extracorporeal membrane oxygenation

Extracorporeal membrane oxygenation (ECMO) may be indicated in cases of near-total obstruction, in patients at substantial risk of worsening respiratory function, or in patients who are unsuitable for conventional airway strategies. Veno-venous ECMO has been described successfully for elective use in complex airway tumours.[16,20] ECMO is not an emergency airway strategy as it requires MDT planning and discussion, and a well-prepared patient and team. Ideally, the patient is cannulated peripherally while awake. ECMO can be established before or after induction and may be weaned after a definitive airway has been secured.[20]

Specific concerns around ECMO use may include the risk of bleeding with a requirement for heparinisation to maintain line patency.[20] This requires close communication and consideration by both the surgeons and perfusion teams with regular monitoring of activated partial thromboplastin time or activated clotting time intraoperatively.

ELECTIVE AIRWAY MANAGEMENT: DECISION-MAKING

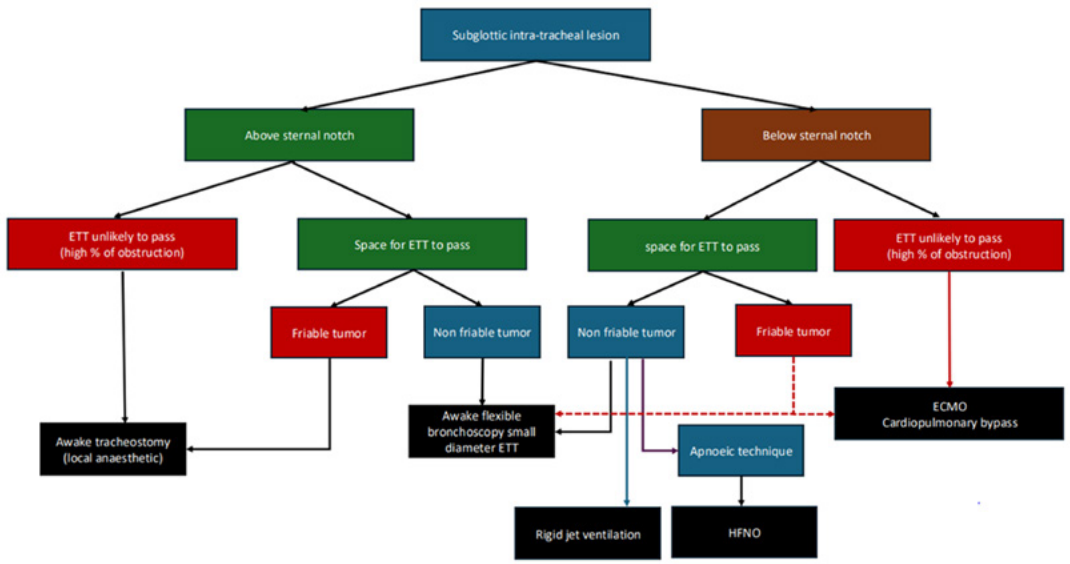
The elective management of patients with subglottic intratracheal lesions requires careful preoperative planning and a tailored approach based on the location of the lesion, degree of airway obstruction, and tumour characteristics.

First phase: Airway control

The first phase allows for initial neck dissection and preparation for tracheal resection.

The first consideration is whether the lesion lies above or below the sternal notch, as this influences both the accessibility of the airway and the feasibility of surgical or endoscopic interventions. Figure 4 demonstrates a suggested algorithm to guide decision-making.

Figure 4. Algorithm for the first phase of airway control for intratracheal lesions (elective)



For lesions above the sternal notch

The first step is to assess whether there is sufficient space for an ETT to pass. Many studies quote *less than 80 per cent obstruction* of the tracheal area as the benchmark for being able to pass an ETT successfully.[16]

Considering the average diameter of an adult trachea is 18 mm, 80 per cent area obstruction leaves a functional airway diameter of about 8 mm. With such a reduction, flow resistance increases exponentially, the work of breathing is dramatically increased, and the airway can become significantly compromised, especially under stress and sedation. Careful individual consideration of the tumour size, its location, the level of obstruction and the available airway equipment is required to guide appropriate and patient-specific decision-making. If the airway remains partially patent and the obstruction is not severe, awake flexible bronchoscopy with insertion of a small-diameter ETT is a preferred approach. When using a fibre-optic scope, it is crucial to ensure that the ETT ID is compatible with scope size. This technique allows for real-time visualisation and minimises the risk of complete airway obstruction during manipulation. However, if there is a high degree of obstruction and the ETT is unlikely to pass the tumour safely, or the lesion is highly friable, an awake tracheostomy under local anaesthetic becomes a safer option, bypassing the obstructed segment entirely.

For lesions below the sternal notch

The first step is to assess the ability of an ETT to bypass the obstruction (as above).

The decision-making process also takes into consideration the friability of the tumour. If the tumour is non-friable and there is enough space for tube passage, cautious intubation may still be considered. Additionally, apnoeic techniques such as rigid jet ventilation or high-flow nasal oxygen (HFNO) may provide effective oxygenation while maintaining a clear surgical field. However, when the lesion below the sternum is considered friable or is severely obstructing the airway, instrumentation risks provoking bleeding or total obstruction.

In such cases, careful MDT planning and consideration of ECMO for airway management may be the better choice. This technique provides a bridge to secure airway control, allowing time-critical interventions without compromising oxygenation and perfusion. In the most complex scenarios, particularly when the airway is nearly or completely occluded, or when neither intubation nor tracheostomy is viable, advanced planning for extracorporeal oxygenation using ECMO or cardiopulmonary bypass is essential. Ultimately, multidisciplinary coordination, including anaesthesia, Ear Nose Throat or thoracic surgeon involvement, and coordination with the perfusion team, is critical to ensure safe and effective management in these high-stakes situations.

Second phase: Open airway phase

Once the trachea is opened, resection and formation of an anastomosis begins. A change in airway may be required to meet the goals of reliable ventilation, a motionless surgical field and minimisation of airway soiling.[21]

The choice of airway must be made in consultation with the surgeon, as this will impact their ability to complete the reconstruction.

Options

- **Continuing with the initial airway placed**
  – Recognising impediment to view and risk of dislodgement.
- **Change in airway management plan**
  – Crossfield intubation.
  – Conventional and safe approach that allows for surgical flexibility.
  – Jet ventilation.
  – ECMO.

VENTILATION STRATEGIES

The literature makes no formal recommendations on ventilation strategy. It is essential to consider the increased airway resistance associated with endotracheal tubes that have an internal diameter smaller than those typically used.

EMERGENCY AIRWAY MANAGEMENT: DECISION-MAKING

Rarely, tracheal lesions may present in an emergency scenario, causing airway obstruction.

Partial airway obstruction (with symptoms such as dyspnoea and stridor) can rapidly evolve into complete airway obstruction and respiratory arrest.

Securing the airway is a critical intervention that can alleviate symptoms and enable the placement of temporary stents. These procedures not only provide immediate relief but also facilitate ongoing multidisciplinary discussions aimed at developing a comprehensive long-term management plan for the lesion.

Decision-making around airway management depends on an evaluation of patient factors, location factors, and team factors. Adam Rehak's synopsis of airway trauma management in the 2019 edition of this journal provides an excellent explanation of how to approach a situation involving a threatened airway, and offers many suggestions applicable to airway obstruction secondary to a tracheal tumour.[22]

Airway completely obstructed

A patient in extremis secondary to an obstructing tracheal tumour requires an immediate response and plan. If unable to optimise or further investigate due to patient deterioration, the initial approach may be to attempt rapid sequence induction, videolaryngoscopy and flexible bronchoscopically-guided ETT placement past the obstructing lesion.

Failure of this technique will require Ear Nose Throat support with rigid bronchoscopy or the implementation of veno-venous ECMO, a technique that requires time to set up and the correct expertise to implement. Respiratory and subsequent cardiovascular arrest are distinct possibilities in these patients.

Airway partially obstructed

If the patient's condition allows time for preparation, planning for airway management and gathering of the appropriate equipment and personnel is essential.

Awake options (such as tracheostomy or flexible bronchoscopy) require a compliant patient and time for local anaesthesia to take effect. An alternative plan should be ready to be implemented should the awake technique fail. If an awake technique cannot be used spontaneous ventilation techniques, where the patient maintains overall airway tone until the airway is secured, are usually preferred.

EXTUBATION PLANNING

Postoperative extubation requires careful consideration. Airway oedema, anastomotic integrity, and residual tumour burden may all impact timing. The presence of a guardian suture (to prevent neck extension and tearing of the anastomosis) coupled with an oedematous, bleeding airway will make re-intubation challenging. However, extubation decreases the trauma of positive pressure ventilation and an endotracheal cuff on a fresh anastomosis.[20]

If extubation is planned in the theatre, bronchoscopy should be performed to visualise the final anastomosis and for airway toileting. Extubation should be smooth and cough-free. A supraglottic device can be placed in the spontaneously ventilating patient as part of a controlled extubation.

A staged approach in the ICU, including bronchoscopic evaluation prior to extubation and a controlled trial of spontaneous ventilation, is common in highly resourced centres. The use of airway exchange catheters or staged airway kits has been considered in previous difficult extubations.[23] Of note, airway exchange catheters are not recommended by the manufacturer as re-intubation adjuncts. Staged extubation kits (containing a soft-tipped wire and a blunt atraumatic catheter) can be utilised for high-risk patients. However, clinicians should be mindful of the fragile tracheal anastomosis and risks of blindly advancing an endotracheal tube during a re-intubation scenario. We recommend a videolaryngoscope-assisted bronchoscopic technique, where the flexible bronchoscope is used as a railroad to safely guide the endotracheal tube past the reconstruction. Where concerns exist, delayed extubation or tracheostomy 2 cm below the anastomosis should be considered.

CONCLUSION

Tracheal tumours pose significant challenges for anaesthetists in airway management. Effectively addressing these cases requires a deep understanding of tumour characteristics, mastery of airway techniques, and a collaborative, team-oriented approach. With careful assessment, thorough preparation, and the ability to adapt intraoperatively, even the most difficult cases can be managed safely.

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