

TRR: Tracheal Resection and Reconstruction

Including some comments on other interventions for tracheal lesions.

Ross's notes - This version 2019_0118.

Please note that these images have been 'stolen' without permission - not for dissemination!

Updated notes, links to presentation etc are available at www.openairway.org/TRR

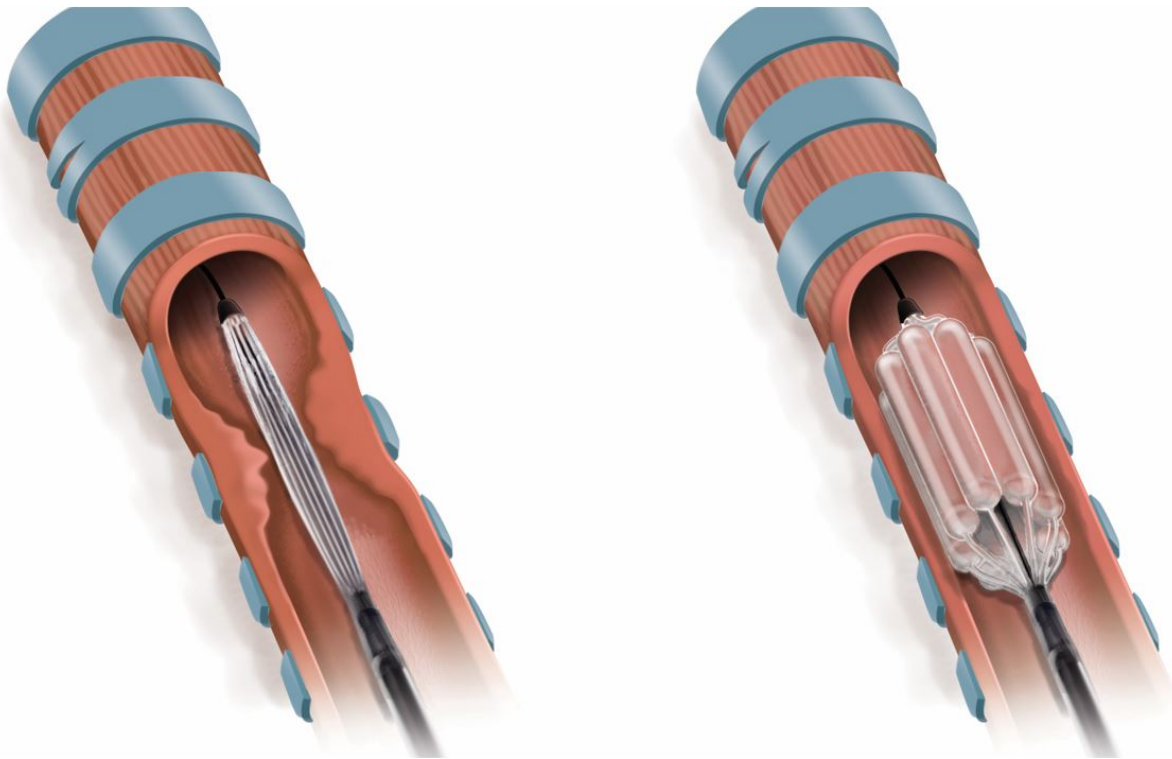
The Special Problem of Tracheal Stenosis

Tracheal stenosis is typically an acquired disease, frequently iatrogenic, and can cause severe functional limitation. Patients often present in extremis with a threatened airway. These acute presentations may result in treatment with tracheostomy, which makes later resection more challenging or impossible, and carries it's own morbidity.

Tracheal stenosis - Management options & brief anaesthetic overview

Tracheal dilatation

- May be performed with solid bougies, balloons or rigid bronchoscopes
- Balloons reduce or remove risk of longitudinal shear forces and perforation, but do carry a (theoretical?) risk of tracheal rupture
- Most bougies/balloons cause complete occlusion, so adequate preoxygenation and tolerance of apnoea is essential
- Non-occlusive balloon is latest technique; very promising results from initial studies in Cape Town. (Hofmeyr *et al.* 2017, 2018)
- Anaesthesia techniques vary based on local practice; our experience is that TCI TIVA (propofol/remifentanyl) with some topical local is very effective. Post-op pain is minimal and easily managed with oral analgesia. Discuss steroids for swelling.
- Airway management is quite dynamic; this is the epitome of the "shared airway" procedure. Take every opportunity to preoxygenate, reoxygenate and provide apnoeic oxygen. Jet or manual ventilation via suspension or rigid bronchoscopy is useful; controlled ventilation via SGA with non-occlusive balloon is the most controlled and relaxing strategy.



Laser incision or resection

- Used either as an adjunct to dilatation (before dilating, to create weak points in circumferential stenosis) or to ablate invasive lesions.
- CO2 laser common; has to be delivered in suspension or via rigid bronchoscope
- Fibre-delivered or diode (Nd-YAG) lasers can work via flexible bronch, and are gaining popularity.
- Anaesthesia technique and airway management is determined by the laser type; TCI TIVA again has large advantages. Fibre-delivered laser via flexible bronch (preferably a single-use, disposable video bronch) introduced through an SGA with continuous ventilation is most elegant method. Minimal post-op pain. Discuss steroids for swelling.
- Unique issues - smoke and airway fire hazard (use lowest achievable FiO2; aim for 0.4 or less; air is fine if SpO2 maintained; no nitrous oxide; helium is awesome for heat dissipation, fire suppression and flow resistance reduction). Closed circuit prevents theatre contamination (theoretical risk of aerosolized viruses with papilloma); high FGF helps prevent smoke soiling of anaesthesia circuit. Beware smoke/soot clogging or damaging the capnography and gas analysis sample line. Consider double HMEFs or an in-line filter for the agent analyzer.
- If intubating with a small tube past lesion, the usual precautions for preventing fire prevail (laser tube, coloured saline-filled cuff, etc).
- Have an airway fire protocol.
- Don't forget eye protection!

Tracheal resection and reconstruction

Surgical resection of part of the large airways (usually trachea, and occasionally carina and/or main bronchi) with reconstruction of trachea using primary anastomosis, prosthetic reconstruction, or t-tube insertion. Indications: Acquired tracheal stenosis (most common in our setting), primary tracheal tumours (common in Developed World), tracheo-oesophageal fistula, congenital abnormalities, vascular lesions, and trauma.

(Seghal 2014) TRR is generally considered to be the definitive surgical management of tracheal stenosis, but is major surgery with a meaningful incidence of failure/reoccurrence and complications.(Grillo 1995)

The normal adult trachea extends approximately 11 cm from the cricoid cartilage to the carina. With laryngeal (suprahyoid release) and hilar mobilization, segmental excisions of up to 50% of total length are possible with primary anastomosis. Despite multiple sources of blood supply, it is highly susceptible to ischaemia from surgical dissection. The recurrent laryngeal nerves run laterally in the groove between the trachea (anterior) and oesophagus (posterior) and thus vulnerable to injury.

As this procedure is uncommonly performed outside of specialist centres; consider asking an experienced colleague for advice/assistance. (Grillo's 1995 publication of the largest series of 503 patients was collected over 27 years!) It is essential to ask the surgeon what their approach is going to be, to allow planning of airway management and analgesic strategy. Always under GA with loco-regional anaesthesia as required. Patients usually extubated on table but admitted to ICU/HCU at least overnight for observation.

Procedure duration 1-6 hours (typically 3-4) with major challenges being airway and ventilatory management through the various phases, and smooth emergence. Post-operative pain is moderate to severe, depending on surgical approach and extent of dissection. Blood loss usually minimal.

Pre-operative assessment & preparation

The airway is often tenuous or threatened pre-op; it is fragile post-op. Anticipated requirement for post-op ventilation is a relative contra-indication for TRR. In acquired/iatrogenic tracheal stenosis, it is important to consider what underlying issues resulted in the period of intubation or tracheostomy that has resulted in stenosis.

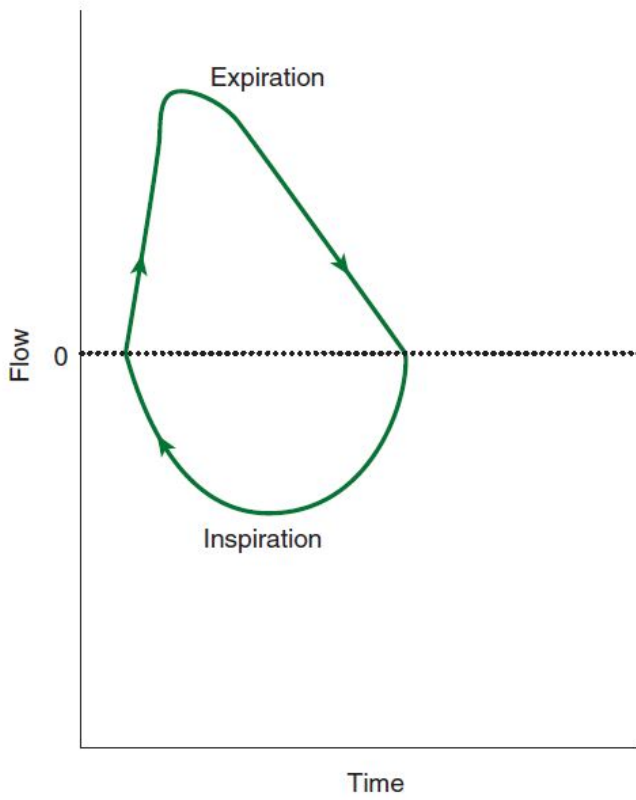
Useful specific history:

- Symptoms of obstruction and/or dyspnoea, especially positional.
- Ability to cough/clear secretions
- Effort tolerance: Symptoms with exertion implies ~50% reduction in tracheal diameter (8-10 mm stenosis); < 5-6 mm diameter will cause increased work of breathing at rest.

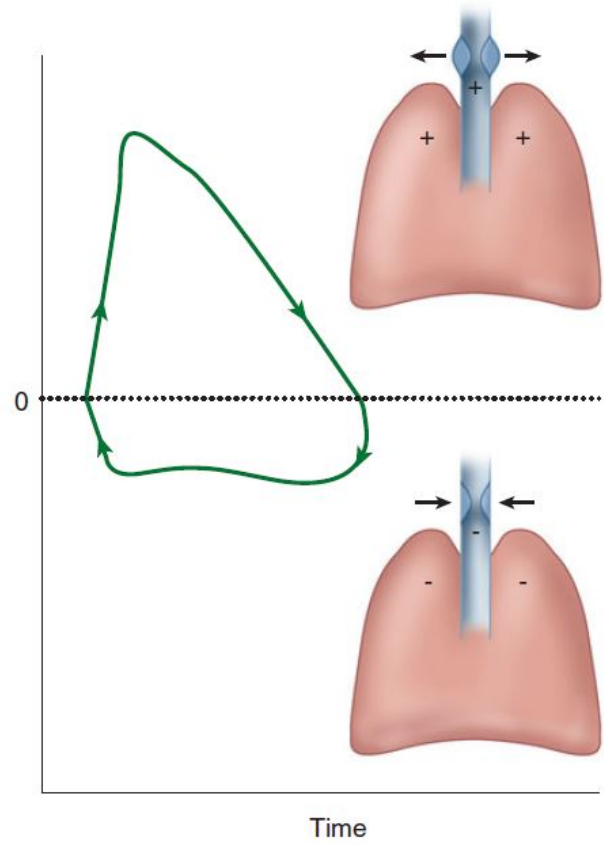
Important examination and investigations:

- Airway evaluation, with consideration for one lung ventilation (OLV).
- Audible stridor implies severe stenosis. Inspiratory stridor is frequently subglottic; expiratory stridor is a sign of stenosis in the lower airway.
- Hb; other bloods at your discretion
- Lung functions if post-op function is in question
- CT (or MRI) chest universally used for planning
- Occasionally barium swallow and/or angio if oesophagus or vascular lesion
- Occasionally preoperative flexible bronchoscopy; bronchoscopy at the commencement of the procedure is common (nearly mandatory).
- Often multidisciplinary team assessment (thoracics, ENT, anaesthesia, pulmonology, ICU)
- Floops traditionally used, but falling out of favour. Blunting of the inspiratory limb suggests a high (extrathoracic) lesion, while blunting of the expiratory limb is intrathoracic in origin. Greatly superseded by accurate location by CT scan, but CT scans give poor *functional* assessment of the dynamic nature of the lesion.

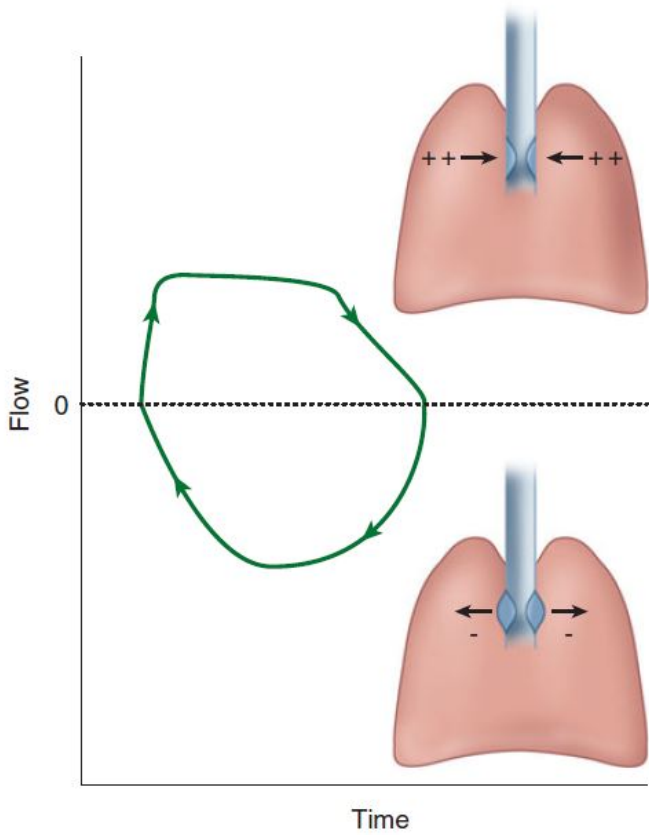
A NORMAL



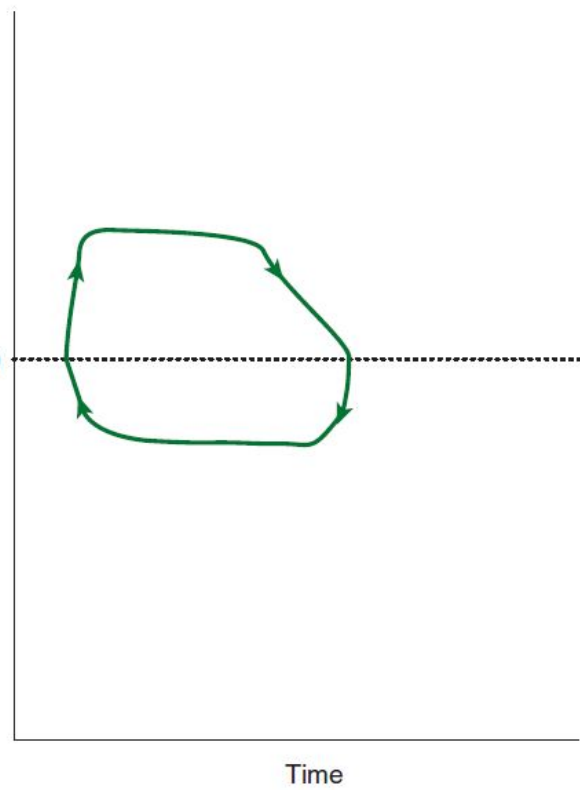
B VARIABLE EXTRATHORACIC OBSTRUCTION



C VARIABLE INTRATHORACIC OBSTRUCTION



D FIXED LARGE AIRWAY OBSTRUCTION



Prehabilitation:

- Smoking cessation (well before surgery)
- Improved effort tolerance
- Chest physiotherapy
- Consider dilatation as bridge to achieving these goals.

Special equipment & theatre preparation

Never embark on a TRR without a direct conversation with the surgeon. This is a shared airway procedure; excellent communication throughout is an absolute necessity.

- 4 mm flexible bronchoscope in theatre
- Equipment for OLV
- Equipment for cross-field ventilation
- Equipment for jet ventilation (ideally high-frequency jet ventilation (HFJV), including machine and Hunsaker tubes)
- Nice to know: ECMO capabilities in case of crisis

Analgesia

Balanced analgesia using short-acting opiates as the mainstay is ideal for the procedure itself. Some advocate using remi- or sufentanil infusion, aiming for emergence with minimal coughing. Oral analgesics with PCA is good for post-op. Field infiltration or superficial cervical plexus blocks useful for neck incision (transverse cervicotomy). If approach includes thoracotomy or sternotomy, consider paravertebral block or epidural.

Monitoring

- All routine monitors, which should definitely include capnography
- Arterial line (left arm or femoral if right thoracotomy, to prevent trace dampening if right innominate is compressed/retracted)
- Pulse oximeter on right arm to alert to innominate compression
- Depth of anaesthesia monitor if using TIVA with NMBA
- Transcutaneous CO₂ is beginning to make an appearance

Anaesthetic strategy

Sandberg writes of 5 phases: 3 critical, 2 calm:

1. Induction & intubation - critical due to airway management & ventilation challenges
2. Dissection - calm
3. Open airway with cross-field or jet ventilation - critical!
4. Closure - calm
5. Emergence and extubation - critical to avoid complications

Pre-induction: Beware sedatives if threatened airway or positional symptoms. Consider anticholinergic if planning bronchoscopy. Good IV access.

Induction: Traditionally inhalational anaesthesia, maintenance of spontaneous ventilation, bronchoscopy and assessment of behaviour with positive pressure ventilation. (Sandberg 2000) However, this is based on perceptions gleaned from external compression of the trachea (eg. mediastinal masses). Prevention of excessive work of breathing and/or coughing, positive pressure ventilation with PEEP and slow controlled ventilation are all advantageous in tracheal stenosis. Author's preference is for TCI TIVA with propofol and opiate (remi or sufentanil depending on expected duration).

Positioning: Position of comfort if patient has positional symptoms, otherwise sniffing/E2SN for induction and airway management. Neck extension with shoulder/scapular roll for cervicotomy or sternotomy; lateral for right thoracotomy; neck flexed for reconstruction and emergence. Consider slight Trendelenberg to reduce aspiration of secretions.

Maintenance: TIVA is optimal; neuromuscular blockade is optional (if not using opiate infusion). Depth of anaesthesia monitoring should be strongly considered. Consider intermittent suctioning of pharynx/larynx to reduce aspiration of secretions.

Emergence: Smooth! Suction everywhere carefully and gently, ideally with under continuous vision with a bronchoscope. Aim for spontaneous breathing with minimal pressure support, then extubation without coughing. Keep neck flexed. Lateral position and/or low-dose opiate infusion may be helpful. Grillo stitch traditionally used, but has lost favour.

Cummings: Otolaryngology: Head & Neck Surgery, 4th ed.

Copyright © 2005, Mosby, Inc.

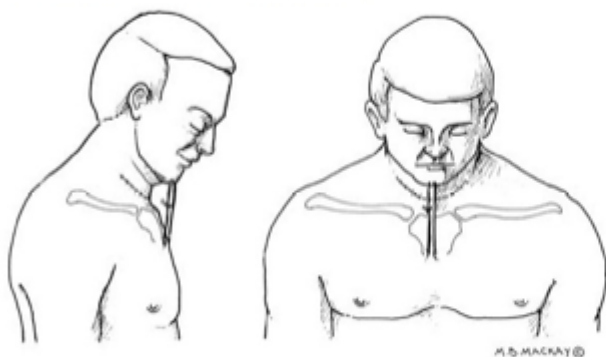
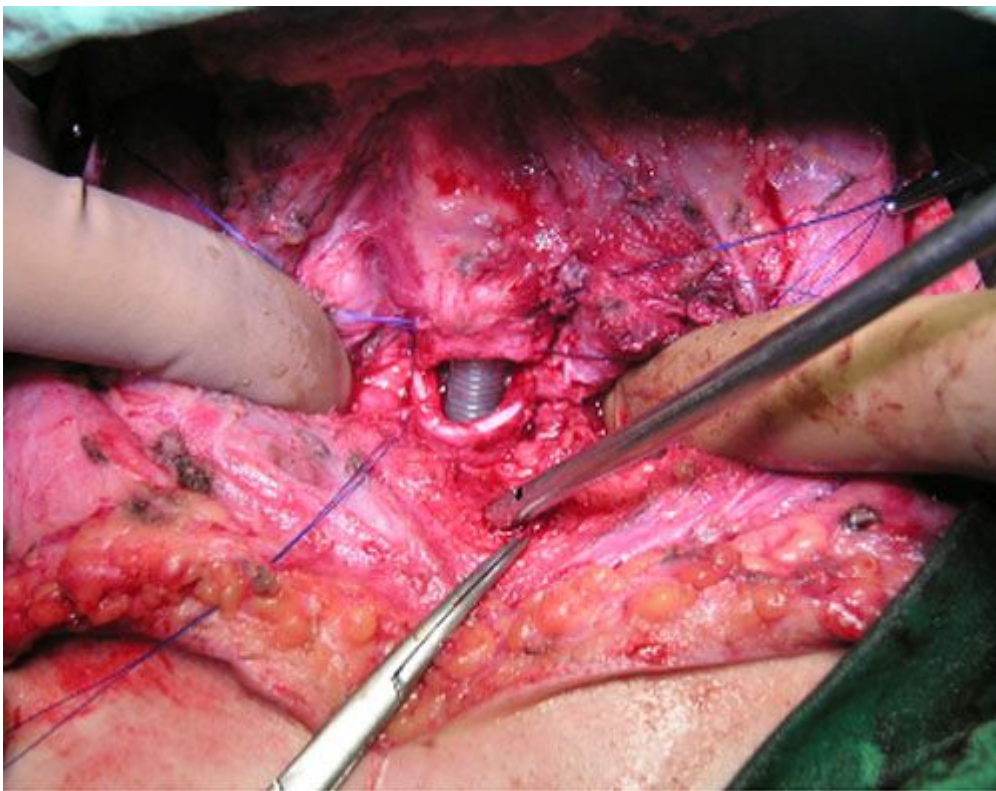
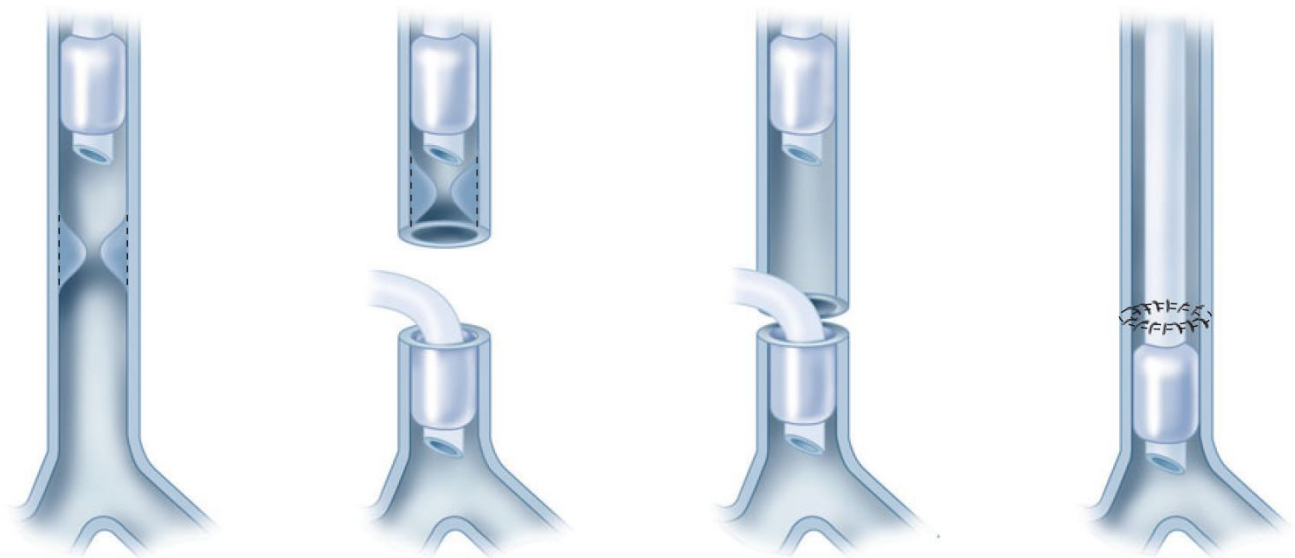


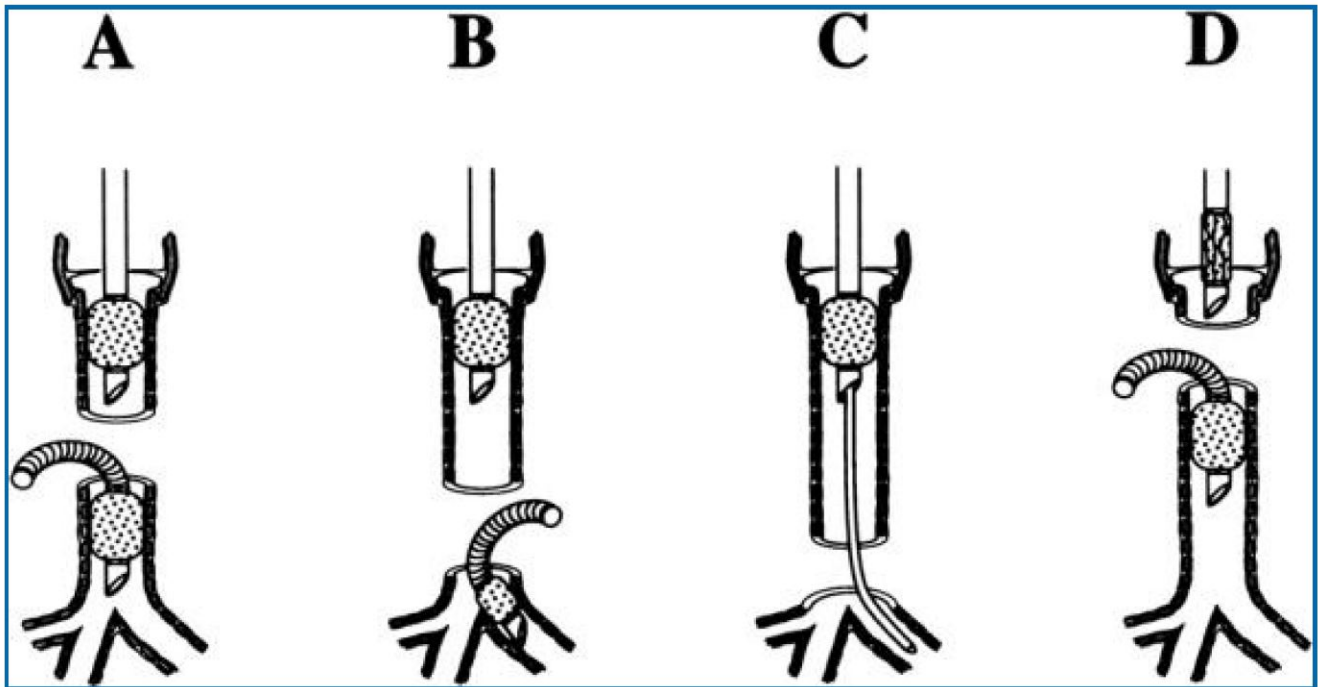
Figure 108-6 Guardian stitch is placed at the end of the operation to maintain neck flexion for the first postoperative week. (Reprinted with permission from F. Griffith Pearson, Joel D. Cooper, Jean Deslauniers, Robert J. Ginsberg, Clement A. Hiebert, G. Alexander Patterson, & Harold C. Urschel, Jr.: *Thoracic surgery*, Churchill Livingstone, 2002, p 411, Figure 19-38.)

Airway & ventilatory strategies

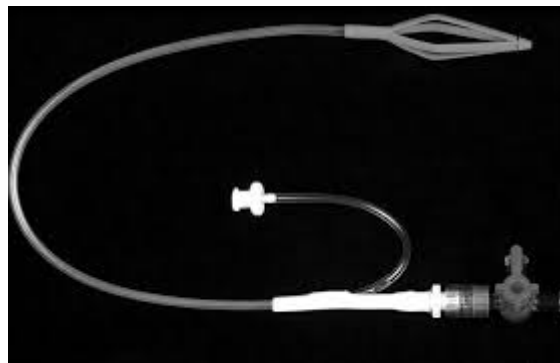
The location, extent and internal diameter of the section to be resected is the greatest determinant of airway management strategy. Similarly, the available airway strategies and devices will determine the options for maintaining oxygenation and ventilation. In the simplest cases, a mid-tracheal lesion will allow intubation on induction, with the ETT cuff above the segment for resection, and normal positive pressure ventilation maintained. Once the initial dissection and mobilization of the trachea has been performed, the trachea is divided, and a sterile ETT and circuit are used to intubate the distal segment of the trachea, allowing cross-field ventilation. Ideally a 'hook/hockey-stick' reinforced tube with short distal tip is used, but any reinforced ETT is suitable. The diseased section is resected, and then posterior wall of the trachea (or graft) is anastomosed. Thereafter, the cross-field ETT is removed, and the original (or a fresh) reinforced oral ETT is advanced beyond the anastomosis. Before each manipulation of the ETTs, the patient should be adequately preoxygenated. Use of a flexible bronchoscope to clear any secretions and carefully confirm tube position is advisable.



Low lesions (close to or involving the carina) make the trachea easy to intubate initially, but pose a challenge during cross-field ventilation. One solution is to intubate one main bronchus (the left is easier) with the cross-field ETT, and perform OLV. The supine position is unfavourable to good V/Q matching on OLV, and may require either low-flow passive oxygenation of the other lung (a sterile suction catheter flowing 1-2 liters/min humidified oxygen can suffice) to maintain adequate saturation. Use of a y-connector from a DLT set can facilitate cross-field intubation of both main bronchi, but this may restrict surgical access. HFJV can also be performed. This has the advantage of good oxygenation with minimal movement of the lung, but requires special equipment. Manual/LFJV is *not* recommended in this setting. THRIVE is under investigation. A downside to open oxygenation techniques (insufflation, HFJV, THRIVE) is that they make monitoring EtCO₂ difficult or impossible, and can flood the surgical field with oxygen, resulting in risk of fire.



High lesions (subglottic stenosis and tumours involving the larynx) are easy to manage during cross-field ventilation, but can make the initial airway management very challenging. Ideally, 20-30 mm of space between the vocal cords and the lesion are required for the "landing zone" of a standard ETT, to allow the cuff to seal. Historically, common approaches included the use of supraglottic or transtracheal jet ventilation, subglottic HFJV with 2-3 mm Hunsaker catheters, or intubation with 4-5 mm ID microlaryngostomy tubes (MLTs). For the former, an ETT can be placed in the larynx as a guide for the jet catheter, and later advanced past the anastomosis. The latter option is elegant if the stenosis allows, as the MLT can be used for the entire case if ventilation is satisfactory.

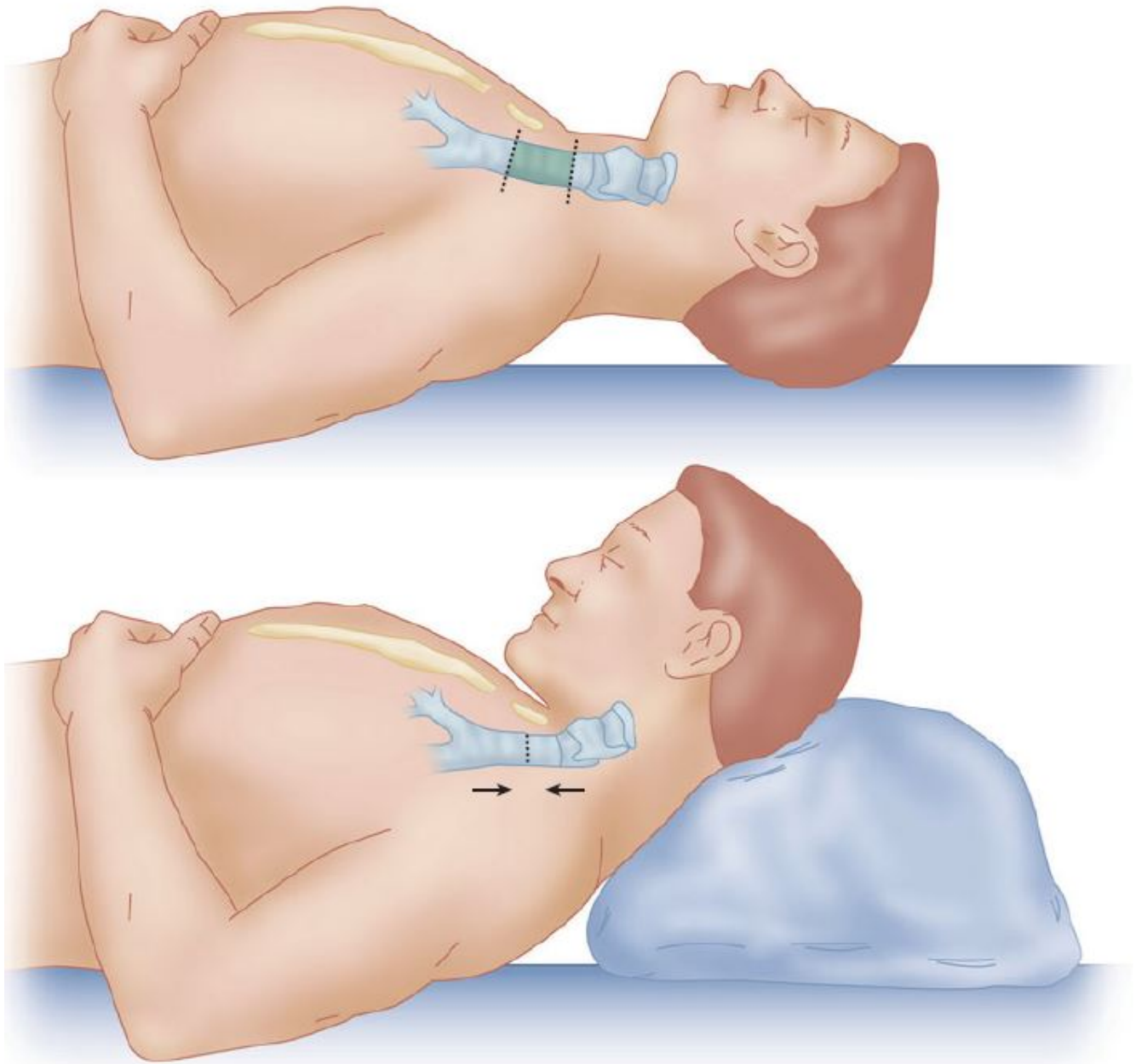


An emerging method is the use of a supraglottic airway (SGA) for initial airway management and ventilation. This avoids the challenges with accurate placement of an ETT, and is an ideal conduit for flexible bronchoscopy prior to commencement of the surgery. It can then serve as a guide for a jet cannula, or be used until distal tracheal/bronchial intubation is achieved. The SGA can be left in situ during the procedure, essentially isolating the airway from oral secretions. The anterior tracheal anastomosis can be achieved with a brief period of apnoeic oxygenation or with an MLT passed through the SGA, and return to spontaneous ventilation and emergence undertaken with SGA alone, avoiding risks of trauma or loss of the airway during ETT removal. If this technique is used, it is advisable to use a modern (2nd or later generation) SGA with good sealing capabilities.

For very challenging cases, ECMO remains a feasible alternative to the airway gymnastics described above. Complex cases involving the larynx are ideally best managed in collaboration with ENT surgeons, and may require specialized surgical approaches such as tracheal slides.

Postoperative considerations

Complications occur in 5-20 % of patients.(Grillo 1995, Auchincloss 2016) The greatest concern is anastomotic dehiscence/breakdown, which has poor outcomes. Risk factors include long segment resections, extensive disease, neoplasia, poor functional status, post-operative ventilation, infection and use of steroids. Bleeding, infections, glottic dysfunction (particularly vocal cord palsies), tracheomalacia and re-stenosis are other complications.



Sources, references and further reading resources:

- Auchincloss HG, Wright CD. Complications after tracheal resection and reconstruction: prevention and treatment. *Journal of Thoracic Disease*. 2016;8(Suppl 2):S160-S7. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4775259/pdf/jtd-08-S2-S160.pdf>
- Grillo HC, Donahue DM, Mathisen DJ, Wain JC, Wright CD. Postintubation tracheal stenosis. Treatment and results. *The Journal of thoracic and cardiovascular surgery*. 1995;109(3):486-92; discussion 92-3. <https://www.ncbi.nlm.nih.gov/pubmed/7877309>

- Hofmeyr R, McGuire J, Park K, Proxenos M, Marwick P, Lubbe D. Initial assessment and development of anaesthesia techniques for use of a novel, non-occlusive tracheal dilatation balloon allowing continuous oxygenation and ventilation (11AP05-9). *European Journal of Anaesthesiology*. 2017;Vol 34, e-Supp 55:273.
- Hofmeyr R, McGuire J, Douglas-Jones P, Proxenos M, Park K, Lubbe D. Multilevel dilatation of tracheal and bronchial stenosis using a non-occlusive tracheal dilatation balloon in a patient with sclerosing airway disease. *Journal of Cardiothoracic and Vascular Anesthesia*. 2017;31(S1):S6-S7.
- Hofmeyr R, McGuire J, Marwick P, Park K, Proxenos M, Lehmann M, et al. Continuous ventilation during tracheal dilatation using a novel, non-occlusive tracheal balloon dilator in an ovine model. *Journal of Cardiothoracic and Vascular Anesthesia*. 2017;31(S1):S84.
- Hofmeyr R, McGuire J, Park K, Proxenos M, Peer S, Lubbe D. First human trial of a non-occlusive dilatation balloon allowing continuous oxygenation and ventilation in the management of tracheal stenosis (11AP06-8). *European Journal of Anaesthesiology*. 2018;35(eSupp 56):278.
- Sandberg W. Anesthesia and airway management for tracheal resection and reconstruction. *Int Anesthesiol Clin*. 2000;38(1):55-75. <https://www.ncbi.nlm.nih.gov/pubmed/10723669>
- Sankalp Sehgal, Joshua C. Chance, and Matthew A. Steliga, "Thoracic Anesthesia and Cross Field Ventilation for Tracheobronchial Injuries: A Challenge for Anesthesiologists," *Case Reports in Anesthesiology*, vol. 2014, Article ID 972762, 5 pages, 2014. <https://doi.org/10.1155/2014/972762>.
- Thoracic Anaesthesia (Oxford Specialist Handbooks in Anaesthesia), Wilkinson & Pennefather (Eds), Oxford University Press, 2011
- UpToDate (latest access 2019/01): Modest, VE. "Anaesthesia for tracheal Surgery". Slinger PD, Hagberg CA (Eds)