Southern African Journal of Anaesthesia and Analgesia. 2021;27(6 Suppl 1):S26-30
https://doi.org/10.36303/SAJAA.2021.27.6.S1.2714

South Afr J Anaesth Analg
ISSN 2220-1181 EISSN 2220-1173

The shared airway

P Nkosi

Department of Anaesthesia, School of Clinical Medicine, Faculty of Health Sciences, Charlotte Maxeke Johannesburg Academic Hospital, University of the Witwatersrand, South Africa
Corresponding author, email: *palesa024@yahoo.com*

Keywords: shared airway, insufflation, THRIVE

Introduction

Airway surgery is a teamwork activity that requires close co-operation and trust between the anaesthetist and the surgeon. In the past, the role of one professional would determine to a large extent the outcome. In the new era, however, the successes in medicine are as a result of an organised multidisciplinary team.[1]

Definition

The shared airway in anaesthesia refers to a situation where the anaesthetist maintains the airway and ventilation of the patient while the surgeon performs the surgery in the same confined anatomic space.

The paediatric airway

Some of the common airway pathology seen are as follows:

1. Laryngomalacia
2. Recurrent respiratory papillomatosis
3. Vallecular cysts
4. Bilateral vocal cord palsies

The following pathological lesions are seen less frequently:

1. Laryngeal clefts
2. Subglottic stenosis
3. Subglottic hemangiomas

The adult airway

Adults tend to present with different pathology – the following are commonly seen:

1. Subglottic stenosis
2. Malignancies, usually trans glottic
3. Papillomata
4. Bilateral vocal cord palsies

Paediatric airway pathology

Laryngomalacia

This is the most common cause of congenital stridor.[2] It is characterised by the softening of the laryngeal tissue that results in the collapse of supraglottic tissue during inspiration (dynamic collapse). This collapse is exacerbated by the supine position, feeding and agitation. The cause is a delay in maturity of supporting structures of the larynx.

The typical presentation is at two weeks of life. The majority are self-limiting and resolve by 12–18 months; it is only about 10% that require surgical intervention.

There are three types of laryngomalacia:[2]

- Type 1 prolapse of mucosa overlying the arytenoid cartilages
- Type 2 foreshortening of the aryepiglottic folds
- Type 3 posterior displacement of epiglottis

The surgical options are based on the type of pathology, which includes the division of the aryepiglottic folds, resection of excess arytenoid tissue, the suspension of prolapsing epiglottis or a tracheostomy.

Recurrent respiratory papillomatosis

This is another common condition. The lesions are normally seen on the true vocal cords and the anterior commissure, but can be found anywhere along the respiratory tract, including the trachea as seen in Figure 2.

The papillomata arise from squamous cells of the respiratory epithelium. The tumours are benign and are due to HPV strains 6 and 7. The typical presentation is at ages 1–5 years. The patient presents with hoarseness, stridor, dyspnoea on exertion. Recurrence is common.

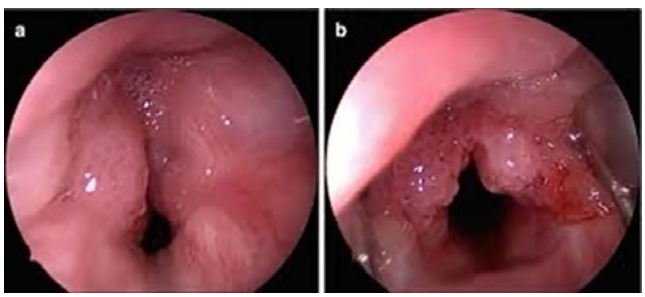

Figure 1a: Pre-debulking **Figure 1b:** Post-debulking

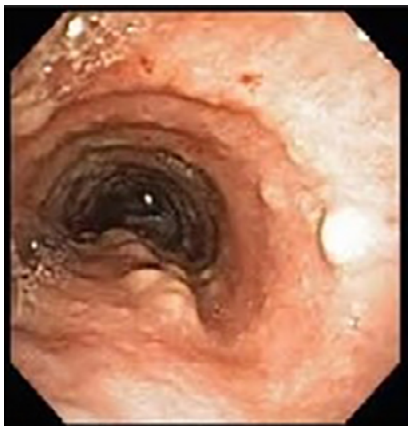

Figure 2: Tracheal papillomata

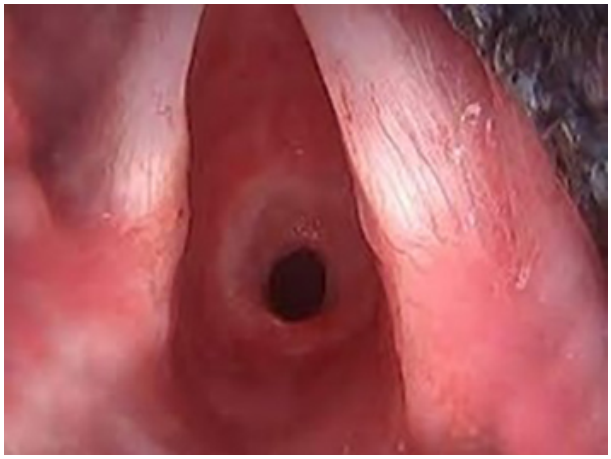

Figure 3: Subglottic stenosis

The best treatment is surgical debulking (Figure 1). Micro debridement and CO_2/radiofrequency ablation are also done, usually without an ETT to prevent seeding of papillomata.

Vallecular cysts and vocal cord palsy are also seen frequently. Vocal cord palsy like larngotracheomalecia, usually presents at or shortly after birth.

Subglottic stenosis

The condition describes the narrowing of the subglottic tracheal lumen. It is defined as the narrowing of the lumen. It can be congenital or acquired. The acquired form is the most prevalent and is due to postintubation laryngeal injury. The stridor is often biphasic, can also present with a barking cough and intercostal recession. The classification is as follows:

Grade1: Luminal obstruction < 50%
Grade 2: 51–70% obstruction
Grade 3: 71–99% obstruction
Grade 4: Complete obstruction

The less severe cases are managed conservatively. The rest are treated with endoscopic dilation or laryngotracheal reconstruction using a costal cartilage graft.

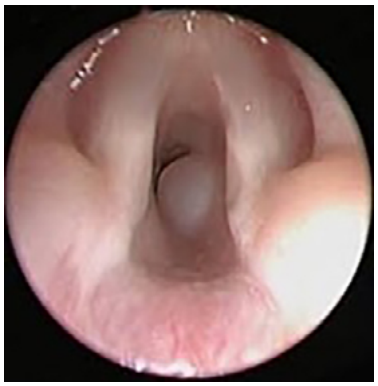

Figure 4: Subglottic cyst

Subglottic cysts

A subglottic cyst is a rare fluid-filled lesion below the vocal cord but sometimes, although rare, can occur in the supraglottic region. The majority are associated with mucosal damage resulting from neonatal intubation. It often presents 4–7 months after extubation. Stridor is a common feature; it too, can recur. The treatment is the marsupialisation of the cyst.

Subglottic haemangiomas

A subglottic haemangioma is a rare vascular anomaly that occurs because of endothelial overgrowth in the submucosa. The lesion normally occurs on the left side but may develop into a circumferential lesion. The child often shows symptoms at 2–6 months of age, invariably with biphasic stridor. There are three phases in the development of the disease. The proliferative phase can last up to a year. This is followed by a quiescence phase that is variable. The involution can be over 2–5 years of life.

Management options can be conservative, i.e. the use of steroids which can be administered systemically or directly into the lesion. CO_2 laser or submucosal resection can also be employed. If the disease is extensive, a tracheostomy is done until involution.

Adult airway pathology

The common pathology seen includes subglottic stenosis, malignancy as well as papillomata and vocal cord palsy. In adults, the major cause of vocal cord paralysis is trauma or previous surgery such as a thyroidectomy. A tracheostomy is often done in the hope that the vocal cord function recovers.

Surgical considerations

Airway surgery is often complex and dangerous, with a high risk of morbidity and mortality. A lot of risk can be mitigated by creating the best surgical conditions for the surgeon, including an airway devoid of instruments and equipment, an immobile and unreactive patient for the duration of the procedure and a safe environment for the use of electrocautery and surgical lasers, especially for minimally invasive endoscopic procedures.

The procedures performed can be diagnostic, endoscopic, or open. Those that are usually done to identify and characterise pathology include the following:

- Direct laryngotracheobronchoscopy (DL)
- Micro direct laryngobronchoscopy (MDL)
- Rigid airway endoscopy

The optimal anaesthetic technique for these procedures is to maintain spontaneous respiration, to ensure that the surgeon can perform a dynamic evaluation, where the following can be assessed:

1. Vocal cord mobility
2. Laryngeal reflexes
3. Neuromuscular abnormalities such as tracheomalacia and laryngomalacia

Endoscopic surgery is usually reserved for intraluminal lesions, e.g. subglottic stenosis, masses. It is important to visualise the anatomy with no obstruction by an ETT. (The absence of the ETT also reduces inflammation.)[3]

Anaesthetic techniques

The anaesthetic plan should be discussed preoperatively with the surgical team. The anaesthetic techniques employed are guided by the airway integrity, the needs of the surgeon, and by the patient's clinical status.

On history, the airway assessment should reveal the following information: The presence, onset and duration of voice changes, as well as previous head and neck procedures (including radiotherapy). The effort tolerance and positional symptoms and any difficulty in swallowing should also be determined.[2]

The examination of the airway will include an assessment of the neck mobility, mouth opening, dentition, and neck circumference as well as the inter incisor, thyromental and thyrohyoid distances. The presence of a physical obstruction or displacement and mobility of laryngeal structures due to the lesion need to be noted as well.

The rest of the clinical assessment should exclude a significant airway abnormality as evidenced by respiratory distress, stridor, the inability to lie flat, or increased oxygen requirements. Obstructive sleep apnoea (OSA) is of concern, especially in children. All these symptoms pose a high risk of complications and a high risk of difficult intubation.

Once the preoperative assessment is done, the decision can then be made as to whether advanced airway equipment is needed. This includes videolaryngoscopes, flexible and rigid bronchoscopes, and tracheostomy sets.

One must anticipate possible bleeding during manipulation, as well as the possibility of obstruction with loss of the ability to ventilate during induction. The standard airway examination alone is not enough to predict a change in airway patency during induction.[4]

Aspects of the anaesthetic

Spontaneous breathing

The induction of anaesthesia can include a volatile agent, while the maintenance of anaesthesia is by way of TIVA. Supplemental oxygen is introduced into the larynx. With this technique an adequate depth of anaesthesia is difficult to ensure. The aim is a minimal response to laryngoscopy and laryngeal suspension while providing sufficient ventilation.[2]

Insufflation is another technique that can be used in a spontaneously breathing patient. It involves the insufflation of volatile anaesthetic to maintain an adequate depth of anaesthesia. Local anaesthetic to the glottis and subglottic area prevents laryngospasm. The insufflation of gases can be done in a number of ways. Firstly, a small catheter can be placed into the nasopharynx just above the laryngeal opening. Secondly, an ETT can be placed through the nasopharynx and emerge just beyond the soft palate. The last method involves insufflation through the side arm or channel of the laryngoscope.

These methods are suitable for infants with subglottic stenosis as the presence of an ETT would impede surgery. Despite a spontaneously breathing patient, the movement of the vocal cords may be minimal or absent if an adequate level of anaesthesia is maintained, which helps the surgeon. This method also provides a laser safe anaesthetic with no potential fuel source within the larynx.

The disadvantages, however, are the lack of airway control and the possibility of the nasopharyngeal catheter migration into the larynx with a laser airway fire risk or into the oesophagus, which can lead to distention and possible regurgitation. Airway soiling and theatre pollution can happen. Using a shortened ETT or a nasopharyngeal airway can solve some of the problems mentioned. A high intensity suction catheter near the mouth will decrease pollution.

Positive pressure ventilation via an ETT

This offers the anaesthetist a secure airway with continuous ventilation. It can be nasal, oral or via a tracheostomy. There are three types of ETTs that can be used. There are standard sized tubes, micro laryngoscopy tubes (smaller diameter tubes), and laser safe tubes.

A standard tube, if pierced by a laser, could cause an airway fire. The cuff of a standard tube is also vulnerable to damage by a laser. The other disadvantage is the difficulty the surgeon faces when trying to work around a large tube in the larynx. The ETT is also easily compressed during surgery.

Microlaryngoscopy tubes (Figure 5) afford the surgeon a better view of laryngeal structures for surgery because of their smaller size.[5] They also have a cuff that protects the patient against aspiration. These tubes may cause a leak if the diameter is too small compared to the patient's airway. Laser safe tubes are made from rubber, silicone or reinforced with steel. The cuffs

Figure 5a: Laser resistant ETT

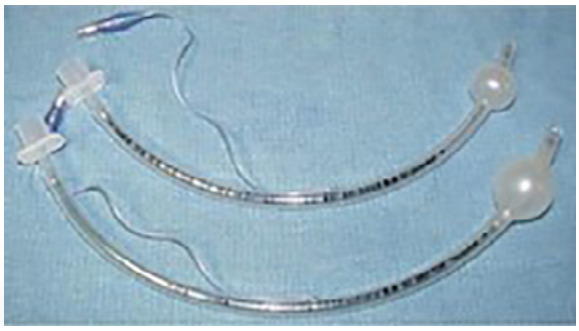

Figure 5b: Micro laryngoscopy ETT

are usually filled with saline which is sometimes dyed blue for detection in case of inadvertent rupture. These tubes are not laser proof but are laser resistant, sustained laser energy strikes can cause an ignition.

Jet ventilation

This is the technique that provides oxygen with entrainment of air. The air/O_2 mixture is administered at high pressures through a small-bore catheter within the airway. It can be at low frequency which is at < 1 HZ, < 60 breaths/min or high frequency at >1 HZ or 60 breaths/min. Jet ventilation can also be categorised by the position at which it enters the airway. It can be via the supraglottic, transglottic and transtracheal position. Only TIVA can be done.

Low-frequency ventilation uses a hand operated switch to deliver rates of 10–20 breaths/min. The user controls the respiratory rate to allow adequate time for exhalation via passive recoil of lungs and chest wall.[2] The advantage of this is that the surgeon has an unobstructed view of the operative field.

High-frequency jet ventilation (HFJV) delivers heated, humidified jet at rates of up to 10 HZ. It is also via a narrow cannula attached to a suspension laryngoscope. It uses lower tidal volumes than the low-frequency technology. Because it gives a continuous expiratory flow of air, fragments of blood and debris can be removed from the airway.

Both low- and high-frequency jet ventilation have a risk of barotrauma as this is a high-pressure system, particularly if the jet is below the larynx. There is no end-tidal CO_2 monitoring making the assessment of the adequacy of ventilation difficult.

The supraglottic jet ventilation technique can use high or low frequency. The jet ventilator catheter attaches to a suspension laryngoscope. The jet must be directed at the glottic opening. It is commonly used for vocal cord polyps or nodules. This form of ventilation allows a clear, unobstructed view, however, patients with stenotic lesions are at risk of air trapping and barotrauma as O_2 may not be able to go past the obstructed area. The airway pressure and end-tidal CO_2 cannot be monitored.

The transglottic approach offers a more efficient mode of ventilation because the jet is directed into the trachea.[4] The catheter is placed below the glottic opening or a rigid bronchoscope is inserted through the vocal cords. The catheter is small, and therefore, the view of the surgical field is reasonable. The advantage of the transglottic approach is that tumour fragments, debris and blood are not blown into the lower airway. A small side port tube allows the monitoring of CO_2. The major disadvantage is that there is a greater risk of barotrauma.

The transtracheal technique is often used in an emergency setting in patients with significant airway pathology.[6] It can be done awake under local anaesthesia, a percutaneous transtracheal catheter is placed through the cricothyroid membrane.[4] This technique can cause airway pressures to rise significantly. Because of decreased exhalation, air trapping occurs, hence it should be avoided in small children. Blocking, kinking of the catheter, infection and bleeding can also arise.

Apnoeic ventilation

Transnasal humidified rapid insufflation ventilatory exchange (THRIVE) is a technique that has been used in the intensive care setting for some time. Its use in the operating theatre for apnoeic ventilation is relatively new.[3] The technique delivers high flow, warm and humidified oxygen via nasal cannulae. The upper airway must be patent for THRIVE to be effective. The continuous high flow oxygen causes bulk flow of gas into the alveoli during apnoea.[7]

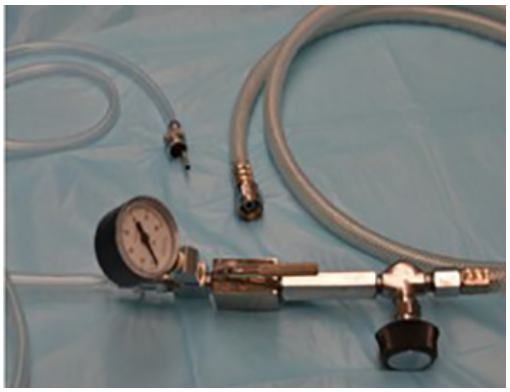

Figure 6: Handheld jet ventilator

Figure 7: Jet ventilator

The high flow of oxygen increases airway pressure, which can improve alveolar recruitment and reduce shunting. Furthermore, the humidified oxygen prevents drying of the nasopharyngeal and tracheobronchial mucosa leading to better patient comfort.[7] This technique affords the surgeon a clear immobile surgical field. It avoids other complications such as barotrauma from jet ventilation and laryngeal trauma from multiple intubations.

It can be used across all age groups. Induction of anaesthesia can happen with or without the addition of muscle relaxants. Although THRIVE can increase apnoea time significantly, it still has limitations. The airway is not protected, and thus, patients remain at risk of reflux and aspiration.[5] It is a technique that is contraindicated in facial fractures and base of skull fractures because of the high flow rate of oxygen. This approach mitigates the risk of airway fires but interruption of surgery is not ideal.

A combination of HFJV and THRIVE is of benefit. It is an option to choose if HFJV or THRIVE alone fails to provide adequate oxygenation.[8] A supraglottic or infraglottic HFJV can be used. The surgical procedure can be completed without interruption for endotracheal intubation.

Cross field ventilation

During tracheal surgery, an ETT is placed directly into the distal trachea or main bronchus through the surgical field. It requires no special equipment; sterile ventilator tubing is used. It is not ideal if the procedure is long and if the tube needs to be intermittently removed to make surgical access possible.

ECMO

This is reserved for patients with a high risk of complete airway collapse during induction of anaesthesia.

Summary

The anaesthetic and surgical teams need to have a clear understanding of their roles in managing the shared airway.[5] The paediatric airway poses significant risk, the competencies and skills required to manage it are broad, therefore, it should be approached as a team.[3]

Conflict of interest

There is no conflict of interest.

Funding source

None.

ORCID

P Nkosi https://orcid.org/0000-0002-8401-3399

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