Anesthesia for Airway Surgery

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Objectives: At the conclusion of this lecture, the participant will be able to:
1. State the indications and options for airway stenting.
2. Discuss pre-anesthetic assessment and planning for patients with or requiring airway stents.
3. Design an anesthetic plan to manage patients for airway stenting.

Rigid Bronchoscopy: Rigid bronchoscopy has traditionally been considered the technique of choice for the preoperative diagnostic assessment of an airway obstruction involving the trachea, and in the therapy of massive hemoptysis and foreign bodies in the airway. The role of interventional bronchoscopy with laser, bronchial dilation, or stent insertion is well established for the palliative treatment of malignant endobronchial lesions as well as for the management of benign central airway lesions\(^1\). Because rigid bronchoscopy is performed with ventilating instrumentation, it is the procedure of choice when operative procedures such as dilation of tracheal stenosis.

Central airway obstruction produces symptoms of dyspnea, stridor, or obstructive pneumonia and is often misdiagnosed as asthma. In most cases, resection and surgical reconstruction provides the best opportunity for definitive management. Bronchoscopic management is the first step in providing a diagnosis, stabilizing the obstructed airway, and evaluating the resection. Interventions commonly used for these patients include: dilation, laser ablation, stenting and palliative creation of an air passage through an obstructing tumor.

Anesthetic Management: Chest radiographs and chest CT scans should be reviewed in the preoperative evaluation. If time permits, it is recommended that patients with severe stridor receive pharmacological interventions for temporary stabilization of the condition. Treatments may include inspired cool saline mist, nebulized racemic epinephrine and the use of systemic steroids\(^2\).

There are four basic methods of ventilation management for rigid bronchoscopy:
1) Spontaneous ventilation. The addition of topical anesthesia or nerve blocks to the airway decreases the tendency to breath-hold and cough when volatile anesthetics are used.
2) Apneic oxygenation (with/without insufflation of oxygen). This requires thorough pre-oxygenation and the anesthesiologist will have to interrupt surgery to ventilate the patient before desaturation occurs. This should allow the surgeon working intervals of 3 min. or longer depending on the underlying condition of the patient.
3) Positive pressure ventilation via a ventilating bronchoscope. This allows the use of a standard anesthetic circuit but may cause significant air-leaks if there is a discrepancy between the size of a smaller bronchoscope and a larger airway.
4) Jet ventilation. This can be performed with a handheld injector such as the Sanders injector\(^3\) or with a high frequency ventilator. These techniques are most useful with intravenous anesthesia since they entrain gas from either the room air or an attached anesthetic circuit and the dose of any volatile agent delivered will be very uncertain.

The use of anticholinergic agents (e.g. glycopyrrolate 0.2 mg IV) prior to manipulation of the airway will decrease secretions during the bronchoscopic examination. For a patient undergoing rigid bronchoscopy, the surgeon must be at the bedside for the induction of anesthesia and be prepared to establish airway control with the rigid bronchoscope. Anesthetic induction, maintained by spontaneous ventilation, with the use of a combined inhalation agent such as sevoflurane, with/without a short acting intravenous agent (such as propofol), may be used until the airway is secured. This is the ideal management in children but may not be tolerated in the elderly due to the cardio-vascular depression associated with high doses of volatile anesthetics.

In cases, for which the use of muscle relaxants is not contraindicated, a short acting agent (succinylcholine) can be used initially to facilitate intubation with either a small single-lumen endotracheal tube or the rigid bronchoscope. Non-depolarizing relaxants may be needed for
prolonged procedures such as stent placement or tumor resection. Mouth-guards should be used to protect the upper and lower teeth and gums from the pressure of the bronchoscope. Remifentanil and propofol infusions can be administered if an intravenous regimen is the planned anesthetic. This is a useful technique if the surgeon needs repeated access (for suction or instrumentation) to the open airway since it maintains the level of anesthesia and avoids contaminating the operating room with exhaled anesthetic vapors.

In cases where an Nd:YAG laser is used, the inspired fraction of oxygen should be maintained in the lowest acceptable range (i.e. less than 40% if possible) according to patient oxygen saturation, to avoid the potential for fire in the airway. Since any common material (including porcelain and metal) can be perforated by the Nd:YAG laser it is best to avoid any potentially combustible substance in the airway when the Nd:YAG laser is used. Due to its high energy and short wavelength the Nd:YAG laser has several advantages for distal airway surgery over the CO2-laser which is used in upper airway surgery: The Nd:YAG laser penetrates tissue more deeply so it causes more coagulation in vascular tumors and it can be refracted and passed in fibers through a flexible or rigid bronchoscope. However, there is a higher potential for accidental reflected laser strikes and there is more delayed airway edema.

Pulse oximetry is vital during rigid bronchoscopy since there is a high risk of desaturation. There is no simple way to monitor end-tidal CO2 or volatile anesthetics since the airway remains essentially open to atmosphere. For prolonged procedures, it is useful to perform repeated arterial blood gas analysis to confirm the adequacy of ventilation. An alternative is to interrupt surgery and ventilate the patient with a standard circuit and a mask or ETT to assess the end-tidal CO2.

With rigid bronchoscopy the airway is never completely secure and there is always the potential for aspiration in patients at increased risk, such as those with a full stomach, hiatus hernia, morbid obesity, etc. It is always best to defer rigid bronchoscopy to decrease the aspiration risk if possible in these patients. When there is no benefit to be gained by deferring and/or the airway risk is acute (e.g. aspiration of an obstructing foreign body) there is no simple solution and each case will need to managed on an individual basis depending on the context and weighing the competing risks.

Other uses of the rigid bronchoscope that require anesthesia include: dilation for benign airway stenosis, core-out of malignant lesions in the trachea, laser ablation of endobronchial and carinal tumors, and therapeutic bronchoscopic interventions before surgical resection of lung cancer. Additionally, interventional bronchoscopy is often used for the management of airway complications following lung transplantation.

Complications of rigid bronchoscopy include: airway perforation, mucosal damage, hemorrhage, post-manipulation airway edema, and potential airway loss at the end of the procedure. In some situations, it may be necessary to keep the patient intubated with a small (i.e. 6.0 mm I.D.) single-lumen endotracheal tube after a rigid bronchoscopy if an edematous airway is suspected or the patient is not able to be extubated. These patients may require the use of steroids and racemic epinephrine via nebulization in the postoperative period.

In situations where oxygenation with conventional means is anticipated to be extremely difficult or impossible, the institution of ECMO has been described prior to rigid bronchoscopy.

Esophago-respiratory Tract Fistula: Esophago-respiratory tract fistula in an adult is most often due to malignancy. Occasionally, the fistula is benign, and may be due to injury by a tracheal tube, trauma, or inflammation. Of the malignant fistulae, approximately 85 percent are secondary to esophageal cancer. In contrast to the pediatric patient with esophago-respiratory tract fistulae, which usually connect the distal esophagus to the posterior tracheal wall, these fistulae may connect to any part of the respiratory tract. In most cases, the fistula can be seen on esophagoscopy or bronchoscopy. In malignant cases, the goal of surgery is usually palliation. The technique of lung isolation will depend on the location of the fistula. One option in adults with a distal tracheal fistula is the use of bilateral small (5-6 mm ID) endobronchial tubes.

Pulmonary Hemorrhage. Massive hemoptysis is defined as expectoration of > 200 ml of blood in 24-48h. The commonest causes are carcinoma, bronchiectasis and trauma (blunt, penetrating, or secondary to a pulmonary artery catheter). Death can occur quickly due to asphyxia. Management requires four sequential
steps: lung isolation, resuscitation, diagnosis and definitive treatment. The anesthesiologist is often called to deal with these cases outside of the operating room. There is no consensus on the best method of lung isolation for these cases. The initial method for lung isolation will depend on the availability of appropriate equipment and an assessment of the patient's airway. All three basic methods of lung isolation have been used: double-lumen tubes, single-lumen endobronchial tubes and bronchial blockers. Fiberoptic bronchoscopy is usually not helpful to position endobronchial tubes or blockers in the presence of torrential pulmonary hemorrhage and lung isolation must be guided by clinical signs (primarily auscultation).

Double-lumen tubes will achieve rapid and secure lung isolation. Even if a left-sided tube enters the right mainstem bronchus only the right upper lobe will be obstructed. However, suctioning large amounts of blood or clots is difficult through the narrow lumens of a double-lumen tube. An option is initial placement of a single-lumen tube for oxygenation and suctioning then replacement with a double-lumen tube either by laryngoscopy or with an appropriate tube exchanger. An uncut single-lumen ETT can be advanced directly into the right mainstem bronchus or rotated 90° counterclockwise for advancement into the left mainstem bronchus. A bronchial blocker will normally pass easily into the right mainstem bronchus and is useful for right-sided hemorrhage (90% of PA catheter induced hemorrhages are right-sided). Except for cases with blunt or penetrating trauma, after lung isolation and resuscitation have been achieved, diagnosis and definitive therapy of massive hemoptysis are now most commonly performed by radiology.

Pulmonary artery (PA) catheter induced hemorrhage. Hemoptysis in a patient with a PA catheter must be assumed to be caused by perforation of a pulmonary vessel by the PA catheter until proven otherwise. The mortality rate may exceed 50%. This complication seems to be occurring less than previously, possibly related to stricter indications for the use of PA catheters and more appropriate management of PA catheters with less reliance on wedge measurements. Therapy for PA catheter induced hemorrhage should follow an organized protocol with some variation depending on the severity of the hemorrhage.

During Weaning from Cardiopulmonary Bypass: Weaning from CPB is one of the times when PA catheter induced hemorrhage is most likely to occur. Management of the PA catheter during CPB by withdrawal from a potential wedge depth and observing the PA pressure waveform to avoid wedging during CPB may decrease the risk of this complication. When hemoptysis does occur in this situation there are several management options available (see Fig. 59-47). The anesthesiologist should resist the temptation to rapidly reverse the anticoagulation in order to quickly discontinue CPB, since this can lead to fatal asphyxiation from hemorrhage. Resumption of full CPB ensures oxygenation while the tracheo-bronchial tree is suctioned and then visualized with fiberoptic bronchoscopy. The use of a pulmonary artery vent may be required to decrease the pulmonary blood flow sufficiently to define the bleeding site (usually the right lower lobe). The pleural cavity should be opened to assess the lung parenchymal damage. Conservative management with lung isolation, avoiding lung resection, is optimal therapy if possible. In patients with persistent hemorrhage who are not candidates for lung resection, temporary lobar pulmonary artery occlusion with a vascular loop during and after weaning from CPB may be an option.

Post-tracheostomy hemorrhage. Hemorrhage in the immediate post-operative period following a tracheostomy is usually from local vessels in the incision such as the anterior jugular or inferior thyroid veins. Massive hemorrhage 1-6 weeks post-operatively is most commonly due to tracheo-innominate artery fistula. A small sentinel bleed occurs in most patients before a massive bleed. The management protocol for tracheo-innominate artery fistula is: Over-inflate the tracheostomy cuff to tamponade the hemorrhage. If this fails: Replace the tracheostomy tube with an oral endotracheal tube. Position the cuff with FOB guidance just above the carina. Digital compression of the innominate artery against the posterior sternum using a finger passed through the tracheostomy stoma. If this fails: Slow withdrawal of the ETT and over-inflation of the cuff to tamponade. Then proceed with definitive therapy: sternotomy and ligation of the innominate artery.

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