# Chapter 10
# Anesthesia for Bronchoscopy

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**Abstract**

- Diagnostic flexible bronchoscopic procedures, such as airway exam, bronchoalveolar lavage, and Transbronchial biopsies (TBBX), are commonly performed under moderate sedation (Wahidi et al., Chest 140(5):1342–1350, 2011).
- Advanced diagnostic bronchoscopic procedure, namely Endobronchial ultrasound fine needle aspiration (EBUS-FNA), can be performed under moderate sedation or general anesthesia. The choice of anesthesia technique is based on the patient's tolerance, co-morbidities, expected duration of the procedure, and the skills of bronchoscopist (Casal et al., Am J Respir Crit Care Med 191(7):796–803, 2015).
- Therapeutic bronchoscopic procedures such as debulking of central airway tumors, management of hemoptysis, and stenting of the central airway are generally performed through the rigid bronchoscope under general anesthesia. Minor therapeutic procedures can be performed through the flexible bronchoscope under moderate sedation (Sarkiss, Curr Opin Pulm Med 17(4):274–278, 2011).

**Keywords** Flexible bronchoscopy • Rigid bronchoscopy • Endobronchial ultrasound • Jet ventilation • Total intravenous anesthesia • Laryngeal mask airway

## Introduction

- Diagnostic flexible bronchoscopic procedures, such as airway exam, bronchoalveolar lavage, and Transbronchial biopsies (TBBX), are commonly performed under moderate sedation [1].
- Advanced diagnostic bronchoscopic procedure, namely Endobronchial ultrasound fine needle aspiration (EBUS-FNA), can be performed under moderate sedation or general anesthesia. The choice of anesthesia technique is based on

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B.G. Goudra, P.M. Singh (eds.), *Out of Operating Room Anesthesia*,
DOI 10.1007/978-3-319-39150-2_10

the patient's tolerance, co-morbidities, expected duration of the procedure, and the skills of bronchoscopist [2].
- Therapeutic bronchoscopic procedures such as debulking of central airway tumors, management of hemoptysis, and stenting of the central airway are generally performed through the rigid bronchoscope under general anesthesia. Minor therapeutic procedures can be performed through the flexible bronchoscope under moderate sedation [3].

## Focused History and Physical Findings in Patients Presenting for the Procedure

### *Upper Airway Assessment*

Irrespective of the anesthesia technique planned for the bronchoscopic procedure a thorough examination of the upper airway is essential for the determination of

- The ability of the patient to maintain an adequate airway while under moderate or deep sedation
- The ease of endotracheal intubation and similarly the insertion of the rigid bronchoscope if need
- The ease of insertion of Laryngeal Mask Airway (LMA) and the likelihood of achieving an adequate seal around the glottic opening and ventilation.

Factors that should alert the anesthesiologist and the bronchoscopist to possible difficulties with airway adequacy and control during the procedure are

- History of obstructive sleep apnea
- High mallampati airway class
- Short thyromental distance and small chin indicating anterior larynx view with direct laryngoscopy
- Upper airway changes secondary to external beam irradiation
  - Edema
  - Fibrosis
  - Poor laryngeal mobility and/or loss of laryngeal click
  - Limited mouth opening
  - Known glottic, supraglottic or infraglottic tumor.

### *Pulmonary Co-morbidities*

Reviewing and understanding the location and ventilatory effects of the airway pathology at hand, is essential for both the anesthesiologist and the bronchoscopist. Computed Tomography (CT) images, Pulmonary function testing and flow volume

loops are fundamental for planning the most suitable type of anesthesia, airway device and mode of ventilation to utilize during a particular airway procedure e.g.,

- Patients with high $FiO_2$ requirement necessitating the use of supplemental oxygen
- Patients with reactive, obstructive or restrictive airway disease
- Upper airway pathology e.g. edema and/or space occupying lesions
- Upper and mid tracheal pathology
- Tumors with ball valve effect
- Tumors and/or infections known to cause airway bleeding

## *Cardiac Co-morbidities*

Cardiac and circulatory co-morbidities can be related or unrelated to the pulmonary pathology.

– Pulmonary and/or mediastinal tumors abutting the heart and major vessels may cause direct mechanical effect or secondary effects on the patient's hemodynamics due to hypoxemia and hypercarbia.
– Cardiac arrhythmias such as atrial fibrillation, premature atrial beats, premature ventricular beats, supraventricular tachycardia and malignant ventricular tachycardia has been reported in patients with various pulmonary pathology.
– Compressive and obstructive effect of the mediastinal pathology on the inflow and outflow of the cardiac chambers e.g., SVC syndrome, pulmonary veins occlusion, pulmonary artery thrombi and emboli, pericardial effusion, and pericardial tamponade.
– Pulmonary hypertension and core pulmonale related to restrictive and obstructive pulmonary disease respectively
– Appropriate choice of anesthesia technique, monitoring devices, and medications to support the circulatory system during the procedure is essential.

## *Laboratory Testing*

Baseline laboratory testing can reflect the effects of the underlying pulmonary pathology as well as guide the anesthesiologist in formulation of the anesthesia plan.

### CBC

- Elevated white cell count could reflect and underlying pulmonary infection or the concurrent intake of steroids for the management of COPD or autoimmune pulmonary diseases.
- Acute anemia can be due to hemoptysis and reflects the amount of blood lost.

- Thrombocytopenia especially in the setting of hemoptysis and/or lung biopsies should alert the anesthesiologist to order a type and screen and have packed RBCs and/or platelet available for transfusion in case of emergency bleeding during a bronchoscopic procedure

### Electrolytes

- Hyponatremia can be associated with para- malignant syndrome encountered in patients with lung cancer
- Hyperkalemia should alert the anesthesiologist to avoid the use of succinylcholine as a muscle relaxant.
- Elevated bicarbonate levels may be related to carbon dioxide retention secondary to obstructive sleep apnea or other ventilator pathology.

### Coagulation Studies

- Simple bronchoscopic procedures such as flexible bronchoscopy for airway exam and broncho-alveolar lavage can be safely performed in patients with coagulopathy.
- Procedures involving biopsy of airway pathology, mediastinal lymphadenopathy and lung parenchymal lesions or rigid bronchoscopy for management of central airway tumor and hemoptysis might necessitate a baseline coagulation studies and correction of the coagulopathy in order to perform the procedure safely.

### Renal and Hepatic Function

Baseline renal and liver function testing can be beneficial in the selection of anesthesia medications based on the drug metabolism and clearance

### Type and Screen

Although massive bleeding is rarely encountered in patients undergoing bronchoscopic procedures, a type and screen is considered judicious in patients undergoing rigid bronchoscopy for central airway tumor debulking and/or hemoptysis management.

## Is the Patient in an Optimum State to Proceed with Anesthesia?

Bronchoscopic procedures are generally considered an urgent procedure to diagnose and/or manage airway or lung pathology.

- The common indications for diagnostic flexible bronchoscopy are
  - Airway exam for detection of airway pathology such as space occupying lesions, infections and source of hemoptysis.
  - Broncho-alveolar Lavage (BAL) to obtain washings from the distal airway to detect bacterial and viral infections and obtain samples for microbiology cultures
  - Transbronchial Biopsies (TBBx) is a blind technique where a needle is inserted through the wall of the tracheobronchial tree to obtain a fine needle aspirate from the lung parenchyma. TBBx is commonly used to diagnose infectious, malignant or autoimmune pathologies of the lung.
- Advanced diagnostic bronchoscopy or Endobronchial Ultrasound Guided fine needle aspiration of mediastinal lymph nodes (EBUS-FNA) can also be considered an urgent procedure where the staging of the mediastinum is essential to formulate the patient's treatment plan. Additionally, EBUS-FNA is used for diagnosis of mediastinal lymphadenopathy of unknown etiology
- Rigid bronchoscopic procedures are frequently emergent and urgent procedures to manage airway obstruction and/or hemoptysis.

Due to the urgent or emergent nature of bronchoscopic procedures patient optimization might not be considered a first priority. However an in depth understanding of the patient's airway pathology is necessary for safe anesthetic management.

## Commonly Used Anesthesia Techniques Including Monitoring with References

In a consensus statement published by the American College of Chest Physicians in 2011, the use of topical anesthesia, analgesia and sedation was suggested in all patients undergoing bronchoscopic procedures. This statement was based on the current literature that advocates the safety of topical anesthesia, analgesia and sedation when the appropriate agent for the appropriate patient has been selected.

### *Topical Anesthesia*

- Topical anesthesia is used to reduce coughing and discomfort during bronchoscopy.
- Lidocaine is the most commonly used agent. The maximum dose of Lidocaine when sprayed in the airway is 8.2 mg/Kg. Dose reduction is recommended in patients with impaired liver function and old age [4].
- The use of other agents such as cocaine, Benzocaine or tetracaine is discouraged due to known side effects of addiction in the case of cocaine and higher incidence of methemoglobinemia with tetracaine and benzocaine.

- Topical anesthetics can be sprayed or applied directly in the airway before and during bronchoscopy. Additionally, transcricoid, transtracheal injections or laryngeal nerve blocks can be used [1].

## *Moderate Sedation*

A single agent or different drug combinations have been studied and proved to be both safe and effective in reducing discomfort, anxiety and coughing during bronchoscopic procedures [1, 3]. The most commonly used agents are benzodiazepines, opioids, propofol, antihistamine and anti-cholinergic drugs

- ***Midazolam*** is the most commonly used benzodiazepine due to its rapid onset of action, rapid peak effect short duration. Midazolam has been associated with prolonged recovery time but without an increase in complication rates. Adverse effects of Benzodiazepine are easily reversed with Flumazenil.
- ***Fentanyl*** similar to Midazolam is a preferred drug for sedation during bronchoscopy due to its rapid onset of action, rapid peak effect and short duration. Fentanyl is commonly used in combination with Midazolam due to their synergistic effect and the additional cough suppressant effect of Fentanyl [5]. Respiratory depression associated with the use of opioids can be easily reversed with Naloxone.
- ***Propofol*** has the same mechanism of action as benzodiazepine with the added advantage of ultra-short onset time, rapid peak and rapid elimination and recovery time [6]. Propofol can be used alone or in combination with other sedative agents.
- ***Anticholinergic agents*** such as Atropine and glycopyrrolate have the theoretical advantage of reducing airway secretions but were proven to confer no advantage of improved lung functions or decreased secretions during bronchoscopy. The AACP consensus statement has advised against their routine use during bronchoscopy [1].

## *General Anesthesia*

### Indications

- General anesthesia is the technique of choice for rigid bronchoscopy and for prolonged procedure or when patient intolerance to the procedure is expected.
- Patient intolerance to the procedure performed under sedation can be due to anxiety, high oxygen requirement, severe airway pathology with high grade airway obstruction and/or hemoptysis

### Techniques

Total intravenous anesthesia with ultra-short acting medications is the technique of choice [7].

- Commonly used medications are propofol, ketamine, remifentanil and dexmedetomidine.
- Care should be taken with the use of muscle relaxants. Muscle weakness and paralysis reduce coughing and motion and thus facilitating the accuracy and ease of airway manipulation during the procedure [3].
- Muscle paralysis should be avoided in patients with airway fistulas to the mediastinum or its structures and when positive pressure ventilation is not feasible due to central airway obstruction [3].

### Airway Devices

- Moderate sedation can be performed while oxygen is delivered via nasal cannula and high flow oxygen as needed. Face mask e.g., POM face mask with a modification to allow for the insertion of the bronchoscope can be used for patients with higher FiO2 requirement. Additionally, non-invasive positive pressure NIPP nasal or face mask with special adaptor for the insertion of the bronchoscope can be used in patients with sleep apnea [8].
- General anesthesia necessitates the presence of an airway devise such as LMA or endotracheal tube (ETT). The LMA has the advantage of being placed above the central airway allowing for complete airway inspection and free mobility of the bronchoscope in the central airway
- The rigid bronchoscope is the most suitable airway device for therapeutic bronchoscopy where airway obstruction, bleeding and/or compression can be safely managed.

### Modes of Ventilation Under General Anesthesia

- Spontaneous Ventilation as described before is necessary in patients with airway fistula where positive pressure ventilation can lead to air leak causing pneumomediastinum, pneumothorax and pneumo-peritonium. Spontaneous ventilation can be achieved through LMA, ETT or rigid bronchoscope. For the rigid bronchoscopy supplemental 100% oxygen can be administered passively thorough the side port of the rigid bronchoscope to allow for delivery of a higher $FiO_2$
- Controlled ventilation whether volume cycled or pressure cycled can be used based on the underlying lung pathology. When LMA is utilized, care should be taken to set airway pressure limit between 20 and 25 Cm $H_2O$ in order to avoid leak around the device. Controlled ventilation through the rigid bronchoscope requires packing of the mouth and occlusion of the nostril to reduce leak.

- Jet Ventilation is the ideal mode of ventilation during rigid bronchoscopy [9, 10]. Care should be taken to keep the side ports of the rigid bronchoscope open to air in order to avoid barotrauma secondary to air trapping.

#### Monitoring

- Standard monitors such as electrocardiogram, pulse oximeter and blood pressure monitoring is mandatory for all cases.
- Additional monitoring are available such as Bispectral index monitoring to titrate the depth of anesthesia especially with the TIVA technique [11]. Non-invasive and invasive arterial and hemodynamic monitoring can be vital when the airway pathology is affecting the circulatory system e.g., massive hemoptysis, SVC syndrome.

## Anticipated Adverse Events

### *Airway Reactivity*

#### Causes

Airway reactivity or bronchospasm can be encountered in patients with predisposing factors undergoing any bronchoscopic procedure e.g.

- History of bronchial asthma or reactive airway disease
- Respiratory infections
- COPD exacerbation
- Airway irritation secondary to bleeding manipulation of the airway by the bronchoscope or other instruments.

#### Management

- Intra-procedural nebulization or inhalation of β- agonists e.g., Albuterol
- Utilization of inhalation agents e.g., Sevoflurane

### *Airway Bleeding*

#### Causes

- Preexisting bleeding source such as central or distal airway tumor, infection or bronchiectasis

- Iatrogenic bleeding related to
  - Biopsy of central airway lesions,
  - Transbronchial lung biopsy (TBBx),
  - Biopsy of mediastinal lymph nodes either blind or ultrasound guided
  - Tumor debulking during rigid bronchoscopy.

**Management**

Airway bleeding should be managed promptly and its management is based on the location and the severity of the bleeding.

- Superficial or mild to moderate bleeding can be managed with topical instillation of cold saline, diluted epinephrine, tranexamic acid or thrombin in the airway
- Anticipated larger volume of bleeding threating to cause flooding of the airway and hypoxemia is best managed with the rigid bronchoscopy inserted in the airway. Different techniques can be used
  - Direct compression and tamponade by the rigid bronchoscopy
  - Argon Plasma Coagulation (APC), LASER or electrocautery

Additionally, tools for lung isolation such as bronchial blockers and double lumen tubes should be readily available and appropriately utilized as a temporizing measure while surgical management is arranged.

## *Hypoxemia*

Hypoxemia during bronchoscopic procedures can be defined as oxygen saturation <90 % for more than 1 min. However, other definitions have been quoted in research articles. Even though hypoxemia is considered an infrequent encounter during bronchoscopy, its cause should be sought and managed appropriately.

**Causes**

Common causes of hypoxemia during bronchoscopy are

- Baseline oxygen dependence
- Frequent suctioning
- Low $FiO_2$ needed during APC, electrocautery and LASER
- Airway bleeding
- Bronchospasm
- Airway obstruction by tumor, bleeding or instruments used for the procedure.

**Management**

- Treat the cause
- Increase oxygen flow through nasal cannula
- Increase $FiO_2$ delivered by using face mask, non-rebreather, non-invasive BIPAP or CPAP mask.
- Persistent hypoxemia unresponsive to increasing oxygen flow and $FiO_2$ delivered warrants intubation with LMA or ETT where 100 % $FiO_2$ can be reliably delivered to the patient.

## *Hypercapnia*

Hypercarbia and Hypercapnia are not reliably detected during bronchoscopy unless the patient has an airway device with $CO_2$ monitoring in place e.g., ETT, LMA. The effect of hypercapnia can be noted in increased somnolence, tachycardia and hypertension.

**Causes**

- Baseline due pulmonary pathology such as COPD, PE, or airway obstruction
- Deep sedation with respiratory depressant medications
- Hypoventilation
- Airway obstruction during the procedure with large bronchoscope (EBUS bronchoscope external diameter of 6.2 mm) and/or other instruments.

**Management**

- Pre-procedure optimization of the patient's pulmonary co-morbidities e.g. inhaled bronchodilator therapy, steroids.
- Utilizing ultra-short acting anesthetics and sedative in order to have minimal to no residual respiratory depression post procedure e.g., propofol, reminfentanil.
- Most patients with an airway device in place can tolerate hypercapnia during bronchoscopy. However care must be taken to reverse the hypercapnia pharmacologically or by hyperventilation before the patient is discharged.
- Hypercapnia in patients without airway device in place may be due to airway obstruction and/or apnea. In such instance pharmacologic reversal of the sedatives and/or insertion of an airway device such as LMA or ETT is necessary to treat the hypercarbia.

### *Airway Obstruction*

#### Causes

- External compression by benign or malignant space occupying lesions e.g., anterior mediastinal mass
- Internal growth in the central airway
- Blood clots, mucous plugs, fungal infection

#### Management

Airway obstruction is managed by the interventional bronchoscopists but it imposes several challenges to the anesthesiologists.

- Selections of the airway device: LMA is preferred for airway examination for upper and mid tracheal lesions in order to avoid obscuring and/or traumatizing the lesion.
- The rigid bronchoscope is an ideal device when the central airway is compressed by external mass as it is able to stent the central airway lumen open facilitating ventilation.
- Large obstructing lesions of the trachea and main bronchi pose a risk of air trapping behind the mass due to ball-valve effect. If the air trapping is disregarded or went unnoticed, hemodynamic instability can ensue due to increased intrathoracic pressure and impediment of the venous return. Increasing the I:E ratio in patients managed with positive pressure ventilation can reduce the risk of air trapping as it allows longer time for the passive exhalation.

## Authors Preferred Technique and the Justification

The authors preferred anesthesia technique for bronchoscopic procedures is the use of Total Intravenous Anesthesia (TIVA) (Table 10.1). Compared to inhalation anesthesia, TIVA guarantees an adequate delivery of the anesthetic irrespective of the changes in the upper and lower airway occurring during the procedure e.g.

- Frequent suctioning of airway secretion, blood and saline washes can alter the concentration of inhalation anesthetic dose delivered to the patient.
- Frequent changes in airway devices used during a procedure, e.g., LMA, rigid bronchoscopy, endotracheal tube (ETT), can lead to interruption in the delivery of inhalation anesthetic and varying depth of anesthesia while the airway device is being exchanged.
- Multiple insertion and removal of the bronchoscope through an airway device during a procedure can lead to leak of the inhalation agent to the environment of the bronchoscopy suite and exposure of the healthcare worker to anesthetic agents.

**Table 10.1** A table to summarize the important aspects of anesthetic management

| | |
|---|---|
| Medication | Short acting or ultra-short acting anesthetics in order to avoid post procedure depression of respiratory function e.g., Propofol, Remifentanil |
| Anesthesia technique | TIVA in most cases. Inhalation anesthesia in patients with reactive airway |
| Ventilation | High $FiO_2$ to maintain adequate saturation, expect and manage Hypercabnia, $FiO_2$ reduction during LASER and cautery in the airway |
| Monitoring | Standard. BIS monitor for the depth of TIVA. Consider invasive or non-invasive hemodynamic monitoring for rigid bronchoscopy cases |
| Airway devices | LMA, rigid bronchoscope and less frequently ETT |
| Recovery | 30–45 min with the use of ultra-short acting anesthetic medications |

However, it is important to note that in the event of bronchospasm during bronchoscopic procedures, inhalation agents are considered a potent bronchodilator and the benefits of its use might outweigh the risks.

The authors preferred airway device for bronchoscopic procedures is the LMA and the rigid bronchoscopy.

- The LMA allows for a complete inspection of the central airway as compared to the ETT. An appropriately placed ETT obscures the upper airway down to the mid-trachea.
- LMA insertion avoid trauma to upper and mid tracheal lesions that can occur with ETT insertion.
- Endotracheal intubation can be performed easily through the LMA if needed
- The large barrel of the rigid bronchoscope allows the bronchoscopist to use a wider variety of instrument to manage the airway pathology.
- The rigid bronchoscope can be used to manage complications that are anticipated during bronchoscopic procedures e.g., tamponade tracheal and bronchial bleeding and coring of tumors obstruction the central airways.

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