



INTERVENTIONAL PULMONARY PROCEDURES

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| Surgical Specialty: | Pulmonology |
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Background:

- General Considerations
 - Commonly performed interventional pulmonary procedures may be either diagnostic or therapeutic.
 - Diagnostic: Endobronchial ultrasound (EBUS) and robotic bronchoscopy.
 - Used to biopsy lung lesions or lymph nodes
 - The EBUS scope is a large-diameter bronchoscope with an ultrasound probe at the distal tip. Ultrasound is used to locate lung lesions or lymph nodes from inside the airway, while a needle is placed through the bronchoscope to perform the biopsy.
 - Robotic bronchoscopy uses a bronchoscope paired with a robotic device to “drive” it to target lung lesions based on preoperative computed tomography (CT) scans. A needle is passed through the bronchoscope to biopsy the lesions.
 - Therapeutic: Cryotherapy, balloon dilation, endobronchial stent, and valve placement. Used to treat stenosis, persistent air leak, and necrotizing pneumonia.
 - These procedures are all performed through a therapeutic bronchoscope
 - Patient management is highly dependent on their lung pathology, with the goal of providing optimal conditions for the pulmonologist to pass a bronchoscope to the site of intervention while maintaining adequate oxygenation and ventilation.
 - These procedures necessitate a shared airway with good communication between the pulmonologist performing the procedure and the anesthesia team. The optimal airway device may be an endotracheal tube, supraglottic airway (SGA) (with or without neuromuscular blockade), or native airway.
- Patient Considerations
 - Patients with lung lesions and lymphadenopathy may have other symptoms of metastatic disease.
 - Anemia
 - Hypercoagulability
 - Malnutrition

- Chronic pain
- Patients undergoing therapeutic procedures will likely have poor baseline pulmonary function.
 - May require supplemental oxygen or CPAP/BiPAP perioperatively
 - Determine if certain positions improve or worsen symptoms and assess the patient's ability to lie flat.

Anesthetic Planning:

- Pre-Anesthetic Evaluation
 - Pre-operative testing will depend on the underlying disease process and the patient's age and comorbidities.
 - A type and screen or crossmatch is indicated if biopsies or interventions are being performed on a highly vascular lesion or in close proximity to major blood vessels.
 - These patients will almost certainly have prior chest X-rays or CT scans available to review.
 - Assess for reduction of the tracheal cross-sectional area, as well as main stem bronchus compression, which increases the risk of complications.¹
 - The location of the target lesion may influence the choice of airway device.
 - Discussions to have with the surgeon/family
 - Code status, as some patients have severe underlying disease
 - ECMO candidacy, especially if there is concern for complete airway collapse
 - Potential for postoperative ventilation and pediatric intensive care unit (PICU) admission
- Specific or Unique Room Set-Up Requirements
 - Airway
 - Airway management will be determined by the procedure to be performed and the patient's size.
 - Options include an endotracheal tube, SGA, or native airway with spontaneous ventilation.
 - The pulmonologist may prefer an SGA for EBUS, as it allows biopsy of areas within the trachea that would be inaccessible with an endotracheal tube in place.
 - Non-depolarizing neuromuscular blockers are often used with SGAs to prevent coughing, improve the likelihood of an accurate sample, and minimize the risk of injury to adjacent structures. Neuromuscular blockade may also reduce the number of needle passes and shorten the procedure time.²
 - For native airway cases, supplemental oxygen can be supplied via nasal canula or face mask with an opening for the scope to pass through.
 - Therapeutic bronchoscopes and EBUS scopes have outer diameters from 5.9 mm up to 7 mm.
 - Discuss with the pulmonologist the intended scope diameter to ensure it is feasible for the patient's size and the chosen airway device.
 - It is recommended that the inner diameter of the endotracheal tube be at least 2 mm larger than the diameter of the bronchoscope; this limits the use of EBUS in small children.³

- Drugs/Infusions
 - Total intravenous anesthesia (TIVA) may be preferable to avoid contaminating the operating room with volatile anesthetics if there is not a tight seal around the bronchoscope. Commonly used medications include:
 - Propofol 100-300 mcg/kg/min titrated to effect
 - Ketamine 0.5-1 mg/kg boluses
 - Dexmedetomidine 0.5-1 mcg/kg boluses or 0.2-1 mcg/kg/hr infusion
 - Remifentanyl 0.5-2 mcg/kg/min infusion
 - Local anesthetic
 - 1-2 mg/kg lidocaine sprayed onto the vocal cords and subglottic area may decrease the response to bronchoscopy.⁴
 - Steroids
 - Discuss intraoperative steroids with oncologist prior to procedure due to risk of modifying tumor histology, as well as risk of tumor lysis syndrome.
 - Dexamethasone 0.2-1 mg/kg, max 20 mg to prevent airway edema.
- Monitors
 - Routine American Society of Anesthesiologists monitors must be used in all patients.
 - An arterial line is only necessary based on the patient's comorbidities.
 - EtCO₂ monitoring may be unreliable when significant leaks are present around the airway device.
- Blood availability
 - Blood products are typically not needed for interventional pulmonary procedures. However, it may be appropriate to have blood available for procedures that involve highly vascular lesions or biopsies taken near large blood vessels.
- Other indicated resources
 - Large anterior mediastinal masses or other obstructive lesions warrant having extracorporeal membrane oxygenation (ECMO) on standby.
 - In the presence of a mediastinal mass, the patient's anesthetic management should follow traditional anesthesia best practices, including:
 - Maintaining spontaneous ventilation
 - Adopting the position the patient tolerates best
 - Being ready to quickly change the patient's position in case of difficult ventilation or a hemodynamic problem
 - More information available in the [Anesthesia for Anterior Mediastinal Mass SPA Case Guide](#)

Intraoperative Considerations:

- General
 - Bronchoscopy is very stimulating—plan to have the patient paralyzed or deeply anesthetized before introducing the bronchoscope.
 - Expect impaired ventilation and high peak pressures in the breathing circuit due to the relatively large bronchoscope.
 - In controlled ventilation, low tidal volumes may help prevent the target lesion from moving during biopsy attempts.

- Induction
 - Assuming the patient can lie flat, either an IV or inhalational induction can be performed.
 - In cases of a mediastinal mass, maintaining spontaneous ventilation and identifying the patient's best tolerated position are crucial.
- Positioning
 - The patient will remain supine for the procedure.
 - The bed is often turned 90 degrees to allow the pulmonologist to stand at the head of the bed.
- Maintenance
 - Medications as described above
- Hemodynamic/Physiologic goals
- The goal is to maintain adequate ventilation and oxygenation through either controlled or spontaneous ventilation.
- Emergence/Disposition
 - Well-tolerated diagnostic procedures typically recover in the postanesthesia care unit (PACU).
 - Inhaled bronchodilators may be useful for preventing or treating bronchospasm.
 - More complicated therapeutic procedures, such as stents or endobronchial valves, may require closer observation in the PICU.
- Post-op Care
 - A small amount of hemoptysis can be expected after diagnostic procedures.
 - Significant airway bleeding or edema may require the patient to remain intubated.

Case-Specific Complications/Pitfalls

- Laryngospasm, bronchospasm, and hypoventilation are common complications of bronchoscopy and must be anticipated and treated promptly.
- Pneumothorax is a potential complication, particularly for peripheral lung biopsies. This may not manifest until the patient is in the PACU and may require chest tube placement.
- Hypoventilation can be difficult to detect due to the bronchoscope obstructing relatively small pediatric airways and the potential for circuit leaks.
 - If there is a concern for hypoventilation and hypercapnia, it is advised to intermittently pause the procedure and remove the bronchoscope to allow adequate ventilation and reduce accumulated CO₂.
- A small amount of bleeding is to be expected during biopsies. Ice cold saline, epinephrine 1:10,000, and tranexamic acid should be readily available for the pulmonologist to apply to areas of significant bleeding.⁵

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