CHAPTER 55

Role of Interventions in Pulmonology

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Interventions are increasingly becoming an indispensable tools in the practice of pulmonology. They are useful as diagnostic as well as therapeutic tools. In this chapter, an attempt is made to provide an overview of some of the most common interventions in pulmonology.

THORACENTESIS (PLEURAL TAP)

Thoracentesis is one of the most common medical procedures performed today[1]. It is a percutaneous procedure during which a needle is inserted into the pleural space and pleural fluid is removed either through the needle or a small bore catheter. Before the procedure, bedside ultrasonography can be used to determine the presence and size of pleural effusions and to look for loculations.[2] During the procedure, it can be used in real time to facilitate anesthesia and then guide needle placement.

Diagnostic thoracentesis is performed to obtain a small volume of fluid (50–100 mL) for the purpose of analysis, which is accomplished with a single percutaneous needle aspiration. A therapeutic thoracentesis is performed to relieve symptoms, such as dyspnea, to relieve hemodynamic compromise or to evacuate the pleural space of infection. The therapeutic thoracentesis is normally accomplished using a temporary catheter that is removed at the end of volume removal.[1]Each technique requires familiarity with the principles of pulmonary and pleural anatomy and physiology.

Indications

Thoracentesis is indicated for the symptomatic treatment of large pleural effusions or for treatment of empyemas. It is also indicated for pleural effusions of any size that require diagnostic analysis.[3]

Contraindications

There are no absolute contraindications for thoracentesis. Relative contraindications include the following:

- Uncorrected bleeding diathesis
- Chest wall cellulitis at the site of puncture

Procedure

Consent should be obtained from the patient or a family member. Once the procedure has been explained to the patient and informed consent obtained, the patient is positioned for the procedure. Thoracentesis is usually performed with the patient in a sitting position, sitting upright with his or her arms resting on a surface, such as a bedside table. The lateral recumbent position can be used if the patient is unable to sit upright.

Bedside ultrasonography is a useful guide for thoracentesis. It can determine the optimal puncture site, improve the administration of local anesthetics, and minimize the complications of the procedure.

In circumstances when ultrasound is not available, patients with a nonloculated, free-flowing effusion, may undergo thoracentesis guided by the physical examination to select the puncture site, using the following landmarks:

- One to two interspaces below the level at which breath sounds decrease or disappear on auscultation, percussion becomes dull, and fremitus disappears
- Above the ninth rib, to avoid subdiaphragmatic puncture
- Midway between the spine and the posterior axillary line, because the ribs are easily palpated in this location.

Preparation of puncture site

Thoracentesis is a sterile procedure. A wide area surrounding the puncture site should be sterilized with 0.05 percent chlorhexidine or 10 percent povidone-iodine solution, prior to placement of sterile drapes around the puncture site.

A sterile drape is placed over the puncture site, and sterile towels are used to establish a large sterile field within which to work. Once the puncture site and surrounding skin is sterilized, local anesthetic should be administered. The epidermis is initially infiltrated with anesthetic using a syringe and 25-gauge needle. Next, a syringe with 1 or 2 percent lidocaine with a 22-gauge needle is inserted, advanced toward the rib, and then "walked" over the superior edge of the rib. Passing the needle over the superior aspect of the rib decreases the risk of injury to the neurovascular bundle, which traverses the inferior rib margin.

As the needle is advanced, aspiration should be attempted every several millimeters by intermittently pulling back on the plunger of the syringe. Anesthetic is injected if there is no return of blood or pleural fluid into the syringe. Once pleural fluid is aspirated, stop advancing the needle and inject additional lignocaine to anaesthetise the highly sensitive parietal pleura. Note the depth of penetration before withdrawing the needle. Attach an 18G cannula to a syringe and advance the needle along in the same plane as the local anaesthetic was injected, ensuring that you continuously pull back on the plunger.

Once pleural fluid is obtained, remove the needle leaving the cannula in place. Cover the open hub of the catheter with a finger to prevent the entry of air into the pleural cavity.

Attach a 50ml syringe with a 3 way tap to the catheter hub and open the tap to the patient and syringe to aspirate 50ml of pleural fluid for diagnostic analysis. Close the 3 way tap to the patient as you distribute the fluid into relevant specimen containers. If performing therapeutic thoracentesis, then attach the extension set to the third port with the free end in a container to collect the pleural fluid.

A "dry" thoracentesis occurs in 7.4 percent of procedures and may result from absence of pleural fluid, incorrect needle placement, thick pleural fluid, or use of an inappropriately short needle. The needle can be withdrawn and reinserted in a slightly different angle if the patient tolerated the initial dry tap.

Complications[4]: Potential complications of thoracentesis include pain at the puncture site, bleeding (eg, hematoma, hemothorax, or hemoperitoneum), pneumothorax, empyema, soft tissue infection, spleen or liver puncture, vasovagal events, seeding the needle tract with tumor, and adverse reactions to the anesthetic or topical antiseptic solutions.

Risk factors for complications associated with thoracentesis[5]

- Patient-related factors
  - Small effusion (< 250 mL)
  - Multiloculated effusion
  - Obesity
  - Patient position (supine position)
  - Mechanical ventilation
- Procedure-related factors
  - Inexperienced or poorly trained operator
  - Lack of ultrasound guidance
  - Drainage of large volumes (> 1,500 mL) of fluid

Post-procedure care

- Perform a post aspiration chest X-Ray
- Provide appropriate analgesia
- Monitor for evidence of any complications: pneumothorax, post expansion pulmonary oedema, bleeding, intra-abdominal organ injury (rare), infection (delayed and rare)

INTERCOSTAL DRAIN

An adequate chest drainage system aims to drain fluid and air and restore the negative pleural pressure facilitating lung expansion.[6]An intercostal drain is a flexible plastic tube that is inserted through the chest wall into the pleural space. It is used to drain pneumothoraces or effusions from the intrathoracic space. All intercostal drains inserted for pleural effusions should be real time ultrasound guided.

Indications

- Unresolved primary pneumothorax greater than 2 cm after 2 attempts at aspiration
- Secondary pneumothorax greater than 2 cm
- Unilateral pleural effusion causing breathlessnesss – insert drain to relieve symptoms and aid diagnosis
- Empyema
- Bilateral pleural effusions if decompensated despite optimal medical management
- Tension pneumothorax after needle decompression
- Palliation of breathlessness in malignant pleural effusions
- To facilitate pleurodesis

Procedure[7]

The most appropriate site for chest tube placement is the 4thor 5th intercostal space in the mid- or anterior- axillary line. Attention to technique in placing the chest tube is vital to avoid complications from the procedure.

Equipment required for an intercostal drain (chest drain/ pleural drain)

- Ultrasound and operator (for effusions)
  - Sterile ultrasound sheath
- Sterile field
  - Sterile dressing pack and gloves
  - 2% Chlorhexadine swabs
- Analgesia
  - 4mls of 1% or 2% Lidocaine
  - Orange (25G) needle (x1)
  - Green (19G) needle (x1)
  - 5ml Syringe (x1)
- Seldinger chest drain kit
- Chest drain tubing and bottle
- Sterile water/saline
- Suture kit
  - Straight needle is ideal
- Sterile dressing

Pre-procedure

Written consent should be gained for: Pain, failure of procedure, bleeding, infection, damage to surrounding structures and pneumothorax if the procedure is for an effusion.

Pre-procedure set-up

- Set up sterile trolley
- Prepare drain
- Pour sterile water/saline into chest drain bottle up to the prime line
- Attach chest drain tubing ensuring the end stays within the package and sterile
- Review imaging and examine patient to confirm side of insertion
- It is advised to have a nurse and a helper to assist during the procedure
- Position the patient with leaning forward with arms out stretched or sat at 90 degrees with arm lifted and hand resting behind their head. In elderly or frail patients the nurse may be required to help support this position.
- If drain is for a pleural effusion then ultrasound area to identify insertion site

Procedure for intercostal drain insertion (chest drain/pleural drain)

- Wash hands and don sterile gown and gloves
- Clean insertion site: either the site identified by ultrasound or – for pneumothorax – insert drain in the "safe triangle"
  - Lower border of axilla to the 5th intercostal space; the lateral edge of pectorails major and the lateral edge of latissimus dorsi
- Apply sterile field
- Insert lignocaine cutaneously, subcutaneously and then into the pleural space.
  - Fluid or air should be able to be aspirated with the green needle
- Take the Seldinger needle and attach this to the 10ml syringe provided
- Insert needle in the same plane as the lignocaine, aspirating as you advance. Insert needle to the same distance as air was aspirated with the green needle. Once air is aspirated inset 0.5cm further and confirm ongoing air aspiration
- Remove the 10ml syringe ensuing you place your thumb over the open needle
- Take the Seldinger wire and insert through the needle. Ensure you hold the wire and needle at all times
- Remove Seldinger needle over the wire
- Take scalpel and make a 0.5cm incision in the skin
  - Scalpel sharp edge should always be facing away from the wire
- Take the Seldinger dilator and pass it over the wire, gently but firmly insert the dilator over the wire through the skin and intercostal muscles
  - Warn the patient they will feel some pushing
  - Do not be too forceful as you will kink the wire
  - If the dilator is not advancing it may indicate you are pushing in the wrong plane or against bone
- Once dilated remove the dilator and pass the chest drain over the wire
  - Ensure that you have a hold of the wire out the end of the drain before advancing
- Insert the drain over the wire and remove the wire
- Attach three way tap to the drain and ensure it is closed
- Then confirm air or fluid aspiration with a syringe via the 3-way tap
- Close 3-way tap once position confirmed and suture drain in place
  - This needs to be firm but not pinch the skin or occlude the drain
- Dress the drain so the insertion sight is visible
- Attach drain to chest drain tubing

Post-procedure

o Place drain on free drainage but monitor closely
  - If the patient has a chronically collapsed lung and you drain more than 1-1.5l in the first 24 hours there is risk of re-expansion pulmonary oedema
- Analgesia
- Post procedure CXR
- Document procedure clearly and document length of drain inserted
- Advise patient to always hold drain bottle below level of insertion
- Respiratory review and advise on onward management

Contraindications

Anticoagulation, coagulopathy, or a bleeding diathesis are relative contraindications in a patient undergoing elective chest tube placement.

Complications - frequently occurring when the tube is inserted with a steel trocar - include hemothorax, dislocation, lung lacerations, and injury to organs in the thoracic or abdominal cavity.[7]

NEWER DRAINAGE DEVICES

A chest tube is a flexible plastic tube that is inserted through the chest wall and into the pleural space or mediastinum. It is used to remove air in the case of pneumothorax or fluid such as in the case of pleural effusion, blood, chyle, or pus when empyema occurs from the intrathoracic space.

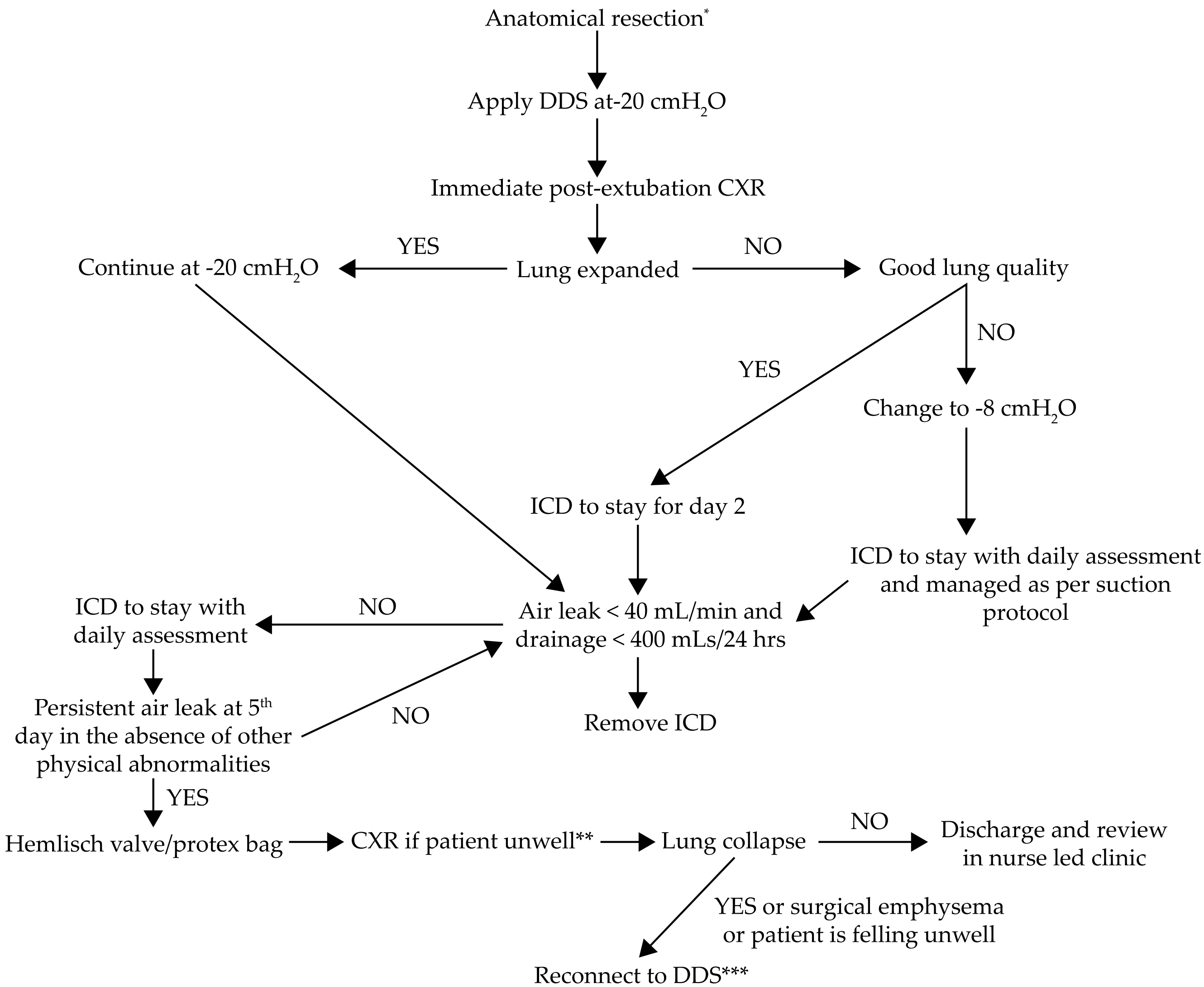

Fig. 1: Flow chart with recommendations of chest tube management following lung resections connected with DDS

The aims for an adequate chest drainage system to be fulfilled are:

- remove fluid & air as promptly as possible
- prevent drained air & fluid from returning to the pleural space, restore negative pressure in the pleural space to re-expand the lung.

Thus, a drainage device must:

- allow air and fluid to leave the chest
- contain a one-way valve to prevent air & fluid returning to the chest
- have design so that the device is below the level of the chest tube for gravity drainage.

An underwater seal chest drainage system is used to restore proper air pressure to the lungs, re-inflate a collapsed lung as well as remove blood and other fluids.[8] The underwater seal drainage system acts as a one-way valve allowing fluid and air to leave the pleuralspace during expiration and coughing but preventing it from being sucked back in during inspiration.[9]

However, there are complications and risks associated with this type of drainage system. If patients have an effective cough combined with a functional underwater seal they may be able to reinflate the lung. However, if the lung does not reinflate or a persistent air leak prevents reinflation, high-volume, low-pressure thoracic suction in the range of 3-5kPa may be used.

The use of suction after thoracic surgery is controversial; some surgeons always use it while others feel it is hazardous.For example, a medical device alert was issued by Medicines and Healthcare products Regulatory Agency (MHRA)after a patient with a chest drain under active wall suction sustained a tension pneumothorax due to the incorrect use of suction systems with no reservoir in situ.[10]

Recently, several companies have manufactured and commercialized new pleural drainage units that incorporate electronic components for the digital quantification of air through chest tubes and, in some instances, pleural pressure assessment. The goal of these systems is to objectify this previously subjective bedside clinical parameter and allow for more objective, consistent measurement of air leaks. The belief is this will lead to quicker and more accurate chest tube management. In addition, some systems feature portable suction devices. These may afford earlier mobilization of patients because the pleural drainage chamber is attached to a battery-powered smart suction device.[11]

Digital drainage systems (DDS) (Figure 1)

All DDS are portable and powered by a rechargeable battery with a sufficiently long run time. They have alarms for various situations, including but not limited to tube occlusion, disconnection and suction failure. Being a completely closed system, the fluid has no contact with the outside environment, and provides improved bio-safety for the health care team and patients themselves. Furthermore these devices eliminate inter-observer variability with objective measurement of air leaks recorded in the system (mL/min) and displayed on a screen.[12]The most important advantage is the ability to apply regulated pressure in the pleural space independent of patient, tube and device position.

The digital thoracic drainage system has been found to be especially beneficial for outpatients undergoing pulmonary resection surgery.The withdrawal of thoracic drainage has been found to be comfortable, safe and well tolerated by patients; it helps to reduce or eliminate the cost of hospital stay, because, according to the different series published in recent months, it is possible to withdraw drainage sooner and thus discharge patients earlier.[13]

Contraindications

Anticoagulation, coagulopathy, or a bleeding diathesis are relative contraindications in a patient undergoing elective chest tube placement. Transudative pleural effusions due to liver failure are not generally managed with thoracostomy drainage.

Blind insertion of a chest tube is dangerous in a patient with pleural adhesions from infection, previous pleurodesis, or prior pulmonary surgery; guidance by ultrasound or computed tomography (CT) scan without contrast is preferred.

THORACOSCOPY

Thoracoscopy (or pleuroscopy) involves passage of an endoscope through the chest wall and offers the clinician a "window" for direct visualization and collection of samples from the pleura. It is a valuable diagnostic procedure and, in some cases, can also provide an opportunity for treatment.[14]

Indications[14]

- Diagnosis of pleural effusion
- Pleural biopsy
- Spontaneous pneumothorax
- Empyema (early stage)
- Bullectomy
- Chemical pleurodesis
- Pulmonary biopsy (forceps)
- Sympatholysis
- Empyema (chronic stage)
- Pulmonary biopsy (stapler)

Preprocedural Considerations[15]

Informed consent is obtained from the patient in preparation for the pleuroscopy. During the preprocedural assessment, the patient's imaging is reviewed. A transthoracic ultrasound may be performed in the pleuroscopy position to ensure adequate fluid quantity and identify a safe location for entry into the pleural space.

Equipment

The standard setup for pleuroscopy includes skin preparation (chlorhexadine swabs), sterile drapes and towels, towel clips, sterile marking pen, local anesthesia (typically 30 mL of 1% lidocaine), hypodermic needles (25 gauge for the skin and 18 or 22 gauge to access pleural space), No. 11 blade scalpel, sterile gauze, Kelly forceps for blunt dissection, trocar port with obturator, pleuroscope (rigid or semirigid with 0° optic), flexible suction catheter (may use rigid suction if rigid pleuroscope used), sterile biopsy forceps, talc poudrage apparatus (if necessary), large-bore chest tube (24F), and needle driver and suture to close skin and secure the chest tube.

Personnel

A dedicated nurse trained in moderate sedation or anesthesia support is necessary for administration of sedation and monitoring of the patient throughout the procedure. A second nurse is required to circulate and assist the physician. One physician with an assistant performs the procedure. All members of the team must be familiar with the procedure, including specimen handling. Once the decision is made to proceed, IV access is obtained, and prophylactic antibiotics are provided to cover skin organisms (usually 1 g cefazolin, or 1 g vancomycin if patient has a penicillin allergy).

Method of anesthesia: Thoracoscopy can be performed under either local or general anesthesia, depending upon the purpose of the procedure.

Indications for thoracoscopy under local anesthesia are inspection of the pleural space, removal of pleural fluid, biopsy of pleura/lung, and talc pleurodesis. Thoracoscopy can be safely performed under local anesthesia in a fully-equipped endoscopy suite under strict sterile precautions.

Thoracoscopy can also be performed under general anesthesia with or without selective bronchial intubation. Single lung ventilation is preferable when video assisted thoracic surgery (VATS) is performed, because selective contralateral lung ventilation permits complete ipsilateral lung deflation.

Procedure — Patients are prepped and sterilely draped in the lateral decubitus position. Monitoring of cardiac rhythm and cutaneous oxygen saturation is necessary.

After the initial preparation, a 10 mm incision is made above the superior rib margin. Simple dissection is performed with a hemostat through the intercostal muscles and parietal pleura. A blunt-tip trocar and cannula are then introduced carefully to avoid lung injury. The site of trocar insertion depends upon the anticipated location of the abnormality.

- The mid-axillary line of the 4th or 5th intercostal space will usually allow complete inspection of the pleura.
- A higher intercostal space is generally preferred for evaluation of spontaneous pneumothorax.
- Metastatic tumor or mesothelioma is more commonly found in the costovertebral angles and on the diaphragmatic surface. These lesions may be more easily accessed through the lower intercostal spaces.

Ultrasound-guided selection of the entry point into the pleural cavity may optimize the chance for success by avoiding adhesions.[16]

Exploration of the pleural cavity is accomplished by maneuvering the telescope in a circular manner. Biopsies of suspicious areas are obtained through either the working channel of the thoracoscope or a separate entry site. Adhesions, which may interfere with complete examination of the pleural cavity, can be lysed with either a blunt probe or cautery forceps, with caution to avoid vascularized adhesions. If the distance between the lung and the chest wall is small, air can be cautiously introduced to collapse the lung further and enlarge the pleural space.

Although the single puncture technique is the most commonly employed method of diagnostic thoracoscopy, some physicians effectively use a double puncture method. With this latter technique, the second site of entry is made under direct video guidance to simplify visualization of difficult to reach areas such as the costovertebral angle, mediastinal pleural surfaces, and the lung apex.

A chest tube is inserted for removal of air and fluid at the completion of the thoracoscopic procedure. Extra holes may be placed in the chest tube to ease fluid drainage after pleurodesis. The chest tube can be removed within a few hours when thoracoscopy does not involve a lung biopsy or pleurodesis.

This approach should lower the cost of the procedure. If thoracoscopy is done for pleurodesis, the chest tube should be left in place until the fluid drainage is less than 150 mL per day. Chest tubes should remain in place until any air leak has resolved. A daily chest radiograph is obtained to assess chest tube position and lung re-expansion.

Contraindications: Major contraindications to thoracoscopy include the inability to enter the pleural space due to pleural adhesions, inability to lay supine, inability to tolerate a pneumothorax, severe cardiac disease, severe respiratory disease unrelated to the effusion, and severe coagulopathy.[17]

Relative contraindications are uncontrolled cough and hypoxemia that is not due to the pleural effusions. When a lung biopsy is being considered, an additional consideration is whether pulmonary hypertension, honeycomb lung, or a vascular tumor is present. As with any intervention, the clinician must routinely evaluate the risks and benefits of the procedure.

BRONCHOSCOPY (FIBEROPTIC AND RIGID)

Bronchoscopy is a procedure that is utilized to visualize the nasal passages, pharynx, larynx, vocal cords, and tracheal bronchial tree.

There are two types of bronchoscopy- flexible and rigid bronchoscopy.The flexible bronchoscope is used more often than the rigid bronchoscope because it usually does not require general anesthesia, is more comfortable for patients, and offers a better view of the smaller airways. Rigid bronchoscopy is usually done with general anesthesia.

The rigid bronchoscope allows evaluation, control, and therapeutic manipulation of the proximal tracheobronchial tree. Massive hemoptysis, foreign body removal, airway stenosis, laser resection, and pediatric bronchoscopy are the most common indications for the rigid bronchoscope.[18]

The flexible bronchoscope offers greater manoeuvrability than the rigid bronchoscope and may be done in conjunction with other procedures, such as bronchoalveolar lavage, transbronchial biopsy, endobronchial ultrasound, electrocautery or laser treatments.[19]

Diagnostic indications for FB[20]

- Suspected neoplasia: lung, tracheal, bronchial, metastatic
- Early detection of lung cancer
- Chest X-ray abnormalities
- Hemoptysis
- Diffuse lung disease/intersticial lung diseases
- Diaphragmatic paralysis
- Vocal cord paralysis, persistent hoarseness
- Persistent cough in selected patients
- Wheezing, stridor and dyspnea
- Suspected pneumonia, lung abscess, study of cavitated lesions
- Lung in filtrates in the immunocompromised patient
- Chest trauma (assessment of tracheal or bronchial rupture)
- Chemical and thermal burns of the airway, smoke inhalation

- Suspected airway fi stula: trachealesophageal, bronchioesophageal, mediastinal, bronchopleural
- Suspected tracheobronchio malacia
- Suspected foreign body in the airway
- Suspected obstruction of the airway
- Evaluation of endotracheal tube positioning
- Evaluation of post transplant patients (status of sutures, stenosis, transplant rejection)
- Persistent lung collapse
- Persistent atelectasis
- Persistent pleural effusion
- Mediastinal adenopathies or masses

Therapeutic indications for FB[20]

- Bronchial washing (broncholithiasis, bronchiectasis, infected lung suppuration, cystic fibrosis)
- Lung lavage (alveolar proteinosis)
- Hemoptysis (bronchial tamponade, placement of Fogarti's catheter)
- Foreign body removal
- Laser, electrocoagulation, cryotherapy, argon plasma coagulation application
- Photodynamic therapy
- Brachytherapy
- Thermoplasty
- Balloon dilatation of stenosis, strictures
- Endobronchial lung volume reduction
- Percutaneous dilatational tracheostomy
- Sealing of bronchopleural fistula/persistent pneumothorax
- Aspiration of bronchial, mediastinal, pericardial cysts
- Diffi cult airway intubation
- Intralesional injection
- Gene therapy

Flexible Bronchoscopy can be performed in a bronchoscopy suit or in the operating room. It can also be performed at the bedside in the ICU or at the emergency room, according to patient location and clinical status.

Basic equipment for flexible bronchoscopy

- Bronchoscope
- Light source
- Cytology brushes
- Biopsy forceps
- Needle aspiration catheters
- Suction
- Containers for samples, syringes
- Supplemental oxygen
- Pulse oximeter
- Sphygmomanometer
- Fluoroscopy
- Resuscitation equipment

Consent[21]

1. Explain the procedure to the patient and allay anxieties. Patients may have heard about the distress associated with a rigid bronchoscope. Explain that the fiberoptic bronchoscope has made the procedure much easier.
2. Assure the patient that there is sufficient room for air to go through.
3. Instruct the patient that he should not talk during the procedure to avoid the likelihood of injury to the vocal cord. However establish some mechanism of communication e.g. instruct to raise fist whenever uncomfortable. If a transbronchial biopsy is planned, cooperation will be required: to take a deep breath and expire slowly.
4. Inform the patient not to expect the results immediately; normally takes two to three days before the histopathological exams are complete.

Pre-screening

- History of allergic reactions to local anaesthetic
- Platelet count, coagulation profile:INR, PT and aPTT
- Urea and creatinine
- Evidence of recent MI/ACS
- If there is a focal lesion present, reveiw all available imaginmake an assessment as the most probable segment
- If there is history of asthma, consider prepare the patient with steroids or administer bronchodilator by inhaler prior to topical anaesthesia.
- If the patient has a history of chronic obstructive pulmonary disease, ascertain baseline O_2 saturation and whether patient has CO_2 retention. In certain cases, respiratory depressants to premedicate may have to avoided, and thus rely primarily on local anaesthesia.
- Medicines: Check whether patient is on aspirin, clopidogrel, Warfarin, or low molecular weight heparin

Premedication

- **Sedation:**
  - Midazolam

- Fentanyl
- Alfentanyl

Preparation

- Pre-Procedure Screening: NBM -The patient should abstain from food and liquids since midnight if the procedure is planned for the morning or after a light breakfast if planned for the afternoon. The stomach should be empty during the procedure to prevent aspiration. As a general rule, food and liquids should be withheld five to six hours prior to the bronchoscopy.
- Assess the need for fluoroscopy: In general, all of the peripheral lesions and transbronchial lung biopsies require fluoro guidance and should be planned for.
- Plan ahead for tests: Anticipate your needs and gather all of the necessary material ahead of time i.e. forceps, specimen bottles, TBNA needle, brush, flumazenil, ice saline, adrenaline etc.
- Oxygenation and monitors: Start the patient on 1-2 liters of oxygen by nasal cannulation as there is an approximate drop of 10-20 mg Hg PO_2 during the procedure. Providing supplemental oxygen prevents hypoxemia during the procedure and the patient's oxygenation status should be monitored by cutaneous oximetry.

Conscious Sedation

Consider starting an IV line and titrate midazolam 1mg at a time, watching the patient's response. Older patients are very sensitive. Therefore, 1 or 2 mg total may suffice. Midazolam also provides amnesia but an excessive dose can induce respiratory depression. Reversal agents Flumazenil must be available.

Monitoring

The occurrence of endoscopically induced arrhythmias and ischemic changes is well documented in both gastroscopy and colonoscopy. However, fiberoptic bronchoscopy, with the additional factor of airway intubation only has a small risk of inducing an arrhythmia. The avoidance of hypoxemia by routine use of supplemental oxygen and the use of topical lignocaine may be of importance. Close monitoring of oxygen saturations, BP and pulse, and level of consciousness in all situations where conscious sedation is done for the procedure is essential.

Administration of Oxygen

1. Nasal cannula
2. A mask with a hole made to permit passage of the bronchoscope
3. Single cushioned naal prong

Instrument

- The bronchoscope consists of a handle and fiberoptic bundle. The light passes from the light source through the fiberoptic bundle to illuminate the bronchus. Newer scopes avail video processing technology
- The knob of the handle controls the position of the tip of the scope: flexion and extension
- There is a channel for suction controlled by a button that is depressed.
- The channel on the side facilitates instillation of anaesthetic or saline and passage of biopsy forceps and instruments.

Routes of Intubation

There are many ways the fiberoptic bronchoscope can be introduced. An awareness of these alternatives is important. Each method has its own unique advantage. The anesthetic procedure will vary depending on the method you have selected.

Transnasal: The transnasal method allows a more stable, aesthetic method, and allows the patients to swallow secretions more easily. The disadvantage is the difficulty beginners seem to have in introduction of the scope and nose bleeding may occur due to injury.

Transoral

- With a mouth bite protects accidental injury to the bronchoscope and is tolerated well by the patient.
- Transoral with soft ET tube: The soft endotracheal tube is slipped over the bronchoscope as a sleeve. The scope is then introduced directly into the trachea. The endotracheal tube is slipped into the trachea. The bronchoscope is withdrawn and a mouth bite is placed about the endotracheal tube for protection. This permits removal and re-insertion of the scope conveniently. This is especially useful in certain interventional procedures.
- Through a rigid bronchoscope: The fiberoptic bronchoscope is introduced after insertion of a rigid bronchoscope. This method used to be practiced by thoracic surgeons in the early days. With increasing familiarity and experience with fiberoptic scope, this method of introduction of the fiberoptic bronchoscope is now rarely done.

Transtracheal

- Via endotracheal tube: When patients are on a ventilator, one can perform a bronchoscopy through an adapter or T-piece. The adapter permits insertion of a bronchoscope and performance of the procedure without the interruption of continuous mechanical ventilation.
- Via tracheostomy: It is easy to introduce the bronchoscope through the tracheostomy stoma or through the tracheostomy tube via an adapter. Instill local anesthetic through the stoma and proceed with bronchoscopy.

The size of the bronchoscope and the endotracheal tube are important considerations. A size 8 tube and larger is required when using a bronchoscope 5.5 mm in diameter.

With smaller tubes, the peak pressures developed by the ventilator become excessive and the risk of pneumothorax becomes higher.

For patients on the ventilator, prior to bronchoscopy increase the oxygen concentration to 100% and increase the tidal volume to account for a leak.

BRONCHIAL ANATOMY

It is essential to familiarize onerself with the segmental anatomy and get a three dimensional feel for the tracheobronchial tree.

1. Starting in the trachea, the C-shaped tracheal rings with the posterior membranous portion normally bulging in during expiration and cough.

2. Preferably inspect the the side opposite to the known abnormal lung.

3. Right bronchial tree: The right main stem bronchus is in line with the trachea and is short. The right upper lobe bronchus branches immediately beyond the carina along the lateral wall. The right intermediate bronchus continues to three orifices. Along the medial wall, is the RML, RLL straight down and the superior segment of the RLL opposite to the RML. The medial basal segment of the RLL will branch off first along the medial side. At the end you will see the posterior, anterior and lateral basal segments (three musketeers) clustered together. Withdraw the scope and a gentle turn of the bronchoscope tip towards the lateral sided will bring the RUL orifice into view with posterior, anterior and apical segments.

4. Left bronchial tree: The left main stem bronchus is at an angulation and longer. Recognize the cardiac pulsation along the inferomedial aspect. At the orifice of the LLL, the superior segment branches off posteriorly. Upon entering the LL, the three basal segments can be seen. The left upper orifice divides into the LUL and lingular. The lingual has superior and inferior segments, the LUL has apical, posterior and anterior segments.

Endobronchial Procedures

- Brushing: The cytology brush can be passed through the bronchoscope to the desired site and the lesion can be brushed. The brush resides inside a protective sheath. Retract the brush into the sheath after brushing. This procedure will avoid the loss of the specimen during withdrawal of the brush.

- Biopsy: Advance the biopsy forceps to the abnormal site. Familiarize yourself with opening and closing the forceps. Moving the handle forward opens the forceps. Under direct vision, advance the opened forceps to the selected site and close it to take a bite of the lesion.

- Lavage: The indications for diagnostic lavage are:

- Sarcoidosis

- Diffuse interstitial fibrosis

- Opportunistic infections

Lavage returns and more frequently with the middle lobe and anterior segments. Wedge the bronchoscope into the selected segment. Slowly instill 20 cc’s of saline and apply suction intermittently to collect the secretions.

- Transbronchial Lung Biopsy: For peripheral lesions and diffuse lung disease, a transbronchial biopsy is indicated, and under fluoroscopic guidance where appropriate. The following lists the value of fluoroscope:

- It is absolutely necessary for placement of the forceps into peripheral lesions that are not visible endobronchially.

- It ensures that the forceps are open.

- It minimizes the risk of a pneumothorax.

For diffuse lung diseases, lateral segment of the right lower lobe is preferred site.

Place the bronchoscope in the lower lobe bronchus and identify the lateral basal segment. Advance the forceps into the segment to about 3 cms near the rib cage. Open the forceps and instruct the patient to take a deep breath while simultaneously advancing the forceps. Advance the forceps until either it wedges, is close to the chest wall or the patient develops pleuritic pain. If the patient complains of pleuritic pain, withdraw the forceps slightly until there is no pain. Ask the patient to expire slowly. Close the forceps at the completion of expiration. Gently withdraw the forceps. You will note a tug on the lung. Advancement during inspiration enables the forceps to go as far as possible into the lung. The end expiration will provide you with the most lung tissue for the biopsy. Multiple biopsies (5-6) are recommended if there is no significant bleeding. Depending on the indication, the specimen should be sent for the following:

- Histology in formalin

- AFB and fungal cultures in saline

- Immunofluorescent stains in saline immediately

- **Transbronchial Needle Aspiration:** The indications for transbronchial needle aspiration are:

- Transcarinal: For purposes of lung cancer staging or for undiagnosed mediastinal nodes.

- For peripheral pulmonary nodules.

- At times, even for endobronchial lesions, it is particularly useful for a submucosal process where the standard biopsy forceps may fail to provide adequate tissue.

- Triple Lumen Catheter:The development of the plugged, double sheathed, telescoping microbiology brush catheter offers a satisfactory method of sampling lower respiratory tract secretions without contamination from the inner

Table 1: Comparison of the two types of EBUS[26]

	Radial probe EBUS	Linear probe EBUS
Transducer	Rotating mechanical transducer	Fixed array of electronic transducer aligned in a curvilinear pattern
View	360° to the long axis of scope	60° parallel to the long axis of the scope
Frequency	20 MHz (12, 30 also available)	5–12 MHz
Tissue penetration	4–5 cm	5 cm
Image quality	Very good. Allows airway layers to be identified	Currently not possible to identify airway layers
Real time TBNA	Not possible	Possible
Doppler to indentify blood vessels	Not possible	Possible

channel of the bronchoscope. The bronchoscope should be positioned in the orifice of the affected pneumonic segmental bronchus. Under direct vision, the sterile catheter is advanced 1-2 cm beyond the tip of the bronchoscope. The inner telescoping cannula containing the sterile brush is advanced, thereby ejection the polyethylene glyco plug. The brush is further advanced beyond the inner cannula to enable sampling of secretions. It is then withdrawn into the inner cannula, prior to removing the catheter from the bronchoscope. The distal portion is then clipped with sterile scissors into the culture medium.

Post Procedure Management

- Observation period: Post bronchoscopy management is mainly followed to screen for complications. The complications of routine bronchoscopy are negligible but is strongly recommended to observe the patient for 90-120 minutes following the bronchoscopy. If a transbronchial lung biopsy was done, the period of observation should be two hours and it is important to get a chest x-ray following a transbronchial biopsy to rule out pneumothorax.
- Instructions to the patient
  - Not to eat or drink for another two hours. The gag reflex should return before he can resume oral consumption.
  - An attendant to drive the patient home.
  - Anticipate a sore throat and take a throat lozenge.
  - Call if a fever, shortness of breath or chest pain develops.
  - Anticipate mild haemoptysis.

Absolute Contraindications[20]

- Lack of informed consent
- Lack of an experienced bronchoscopist to perform or closely supervise the procedure
- Lack of adequate facilities and personnel to care for emergencies that can occur, such as cardiopulmonary arrest, pneumothorax or bleeding
- Inability to adequately oxygenate the patient during the procedure.

ENDOBRONCHIAL ULTRASOUND (EBUS)

Endobronchial ultrasound (EBUS) is a bronchoscopic technique that uses ultrasound to visualize structures within the airway wall, lung, and mediastinum.[22]Originally, it was developed for the staging and diagnosis of lung cancer, but its use rapidly expanded to other malignancies and even benign disease.[23]Extending the view beyond the airway wall, EBUS provides evaluation of tumor involvement of tracheobronchial wall and mediastinum and plays an essential role as a guidance technique for peripheral pulmonary diseases.[24]

EBUS technology is currently available in two forms: radial and linear transducer probes (Table 1). Ultrasound images are generated when high frequency sound energy is emitted by a transducer, reflected off a tissue interface, then received by the same transducer and finally processed. The challenge of ultrasonography of the lungs is related to the acoustic properties of air, which reflects ultrasound waves and permits no transmission. This results in images with multiple artefacts and obscures structures within the thorax that are not air-filled. By miniaturizing transducer probes such that they can be inserted via flexible bronchoscopy, these limitations are overcome because mediastinal and peri-bronchial structures can be visualized without intervening alveoli obscuring the view.[25]

Indications[27]

EBUS has become the standard of care and has rapidly attained a key status in the diagnosis and staging of various lung cancers, but in addition is also aiding and helping manage other pulmonary pathologies such as sarcoidosis, lymphoma, and in situ endobronchial lesions. The ability of EBUS to help perform mediastinal and transbronchial biopsies less invasively and with better sensitivity and specificity makes it more favorable than mediastinoscopy.

Contraindications[28]

Contraindications to EBUS are similar to those of bronchoscopy in general. Recent myocardial infarction or ischemia, poorly controlled heart failure, significant hemodynamic instability, chronic obstructive pulmonary disease or asthma exacerbations, or life-threatening cardiac dysrhythmias should delay an endobronchial procedure. Contraindications particular to EBUS-TBNA are related to coagulopathies (medication induced or inherent). The recommendation is to hold antiplatelet and anticoagulation agents prior to endoscopy to reduce bleeding risk.

Technique[27]

EBUS may be performed under conscious sedation or general anesthesia depending on the anticipated length of the procedure. Local anesthetic may be administered to minimize cough, and the flexible bronchoscope is advanced for an initial airway exam. Bronchial segments and subsegments are identified, secretions are suctioned, and 1% to 2% lidocaine is administered to further minimize cough.

After initial airway examination, the flexible bronchoscope is removed and the EBUS bronchoscope is advanced. While EBUS is performed, the bronchoscopist simultaneously visualizes the ultrasonic and bronchoscopic views on display. EBUS can help differentiate normal parenchyma from malignant tissue by its sonographic appearance. The sonographic visualization of normal alveolar tissue is described as a "snowstorm" appearance.

After sonographic confirmation of the biopsy site, the transbronchial needle aspiration (TBNA) needle is advanced through a 2.2 mm working channel on the bronchoscope. This needle may be 21 or 22 gauge and can be advanced up to 40 mm. A stylet or wire is present in the needle at the time of insertion to clear tissue that may have collected while crossing the bronchial or tracheal wall. The distal end of the needle is grooved, rendering it hyperechoic and improving ultrasound visualization. After the lymph node or tumor is punctured, the needle is connected to suction and excursions are made in the lymph node. Multiple punctures have been recommended to decrease sampling error.

The samples obtained can either be analyzed on site by the use of rapid on-site evaluation (ROSE) or collected in saline or cell culture media. The application of ROSE has been shown to significantly lower the need for additional bronchoscopic procedures and puncture number. ROSE is particularly beneficial when performing EBUS in the operating room with an expected need for further invasive exploration or surgical resection. Procedure length varies by the number of lymph node stations sampled. When EBUS is performed in the outpatient setting, patients can be discharged home after they regain their gag reflex.

The anatomical lymph node stations that are accessible via EBUS are 2R, 2L, 3P, 4R, 4L and 7. A unique advantage of EBUS is the accessibility of stations 10R, 10L, 11R, and 11L, which are inaccessible by other invasive techniques.

Endoscopic ultrasound (EUS) also provides access to 7, but in addition lymph node stations 8 and 9 can be accessed. EBUS may be performed safely in a single session alongside EUS. EBUS is preferred as a primary procedure when EUS is performed in the same session.

Complications[29]

EBUS and EBUS-TBNA are usually safe procedures. No serious complications were found on a systematic review of effectiveness and safety of CP-EBUS-TBNA of regional lymph nodes.Reported complications are agitation, cough, hypoxia, laryngeal injury, fever, bacteremia and infection, bleeding, pneumothorax, and broken equipment becoming stuck in the airway. Complications related to upper airway local anesthesia are laryngospasm, laryngeal edema, bronchospasm, methemoglobinemia, and cardiac arrhythmias.Complications attributable to procedural sedation are respiratory depression, cardiovascular instability, vomiting, and aspiration.

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