12 Anesthesia for Lung Resection and Pleural Surgery

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12.1 Introduction

Pulmonary resection and pleural surgeries are the most common thoracic surgical procedures performed in any thoracic surgical unit. Lung resection procedures include wedge resection, segmentectomy, lobectomy, sleeve lobectomy, and pneumonectomy [1], whereas pleural surgeries encompass debridement, decortication, and pleurodesis [2]. Other miscellaneous thoracic surgical procedures include thoracic duct ligation, closure of bronchopleural fistula sympathectomy and several others. These procedures can be performed either by open thoracotomy or video-assisted thoracoscopic surgery (VATS). Advancement in surgical techniques and instrumentation has led to increased interest in thoracoscopic, especially VATS, procedures. VATS was initially used only for minor procedures, but recently it has gained popularity in lung resection and pleural surgeries as well [3]. In fact they are considered to be of choice in most cases due to enhanced recovery, decreased length of stay, and sparing of mechanical chest wall function [4, 5].

Most of the lung resections are related to lung malignancy, tuberculosis (TB) and its clinical sequelae, fungal infections and trauma. However, pleural pathologies like presence of pneumothorax, pleural effusion, hemothorax, chylothorax, empyema, or pleural-based tumors (malignant mesothelioma) warrant surgical intervention to treat the pathology.

The factors to be considered while managing these patients include:

1. Age
2. Pack year smoking
3. Preexisting lung disease
4. Preoperative chemotherapy
5. Baseline lung function
6. Additional comorbidities
7. Nature of surgical procedure
8. Amount of pulmonary resection
9. Open vs VATS (surgical approach)

However, the risk of postoperative respiratory complications (atelectasis, pneumonia, and ARDS) increases to a greater extent in lobectomy and pneumonectomy, where more extensive lung resection is done.

Surgical procedures on and around the lungs require proper knowledge of techniques for lung isolation, ventilation and oxygenation. Knowing tracheobronchial anatomy and airway equipment for one-lung ventilation is of paramount importance [6].

During pulmonary resection surgery, the pulmonary artery, vein, and bronchus are identified and divided at various levels according to the type of resection performed. It is done at the segmental level in segmentectomy,

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bronchial level in lobectomy, and at main stem bronchus level in pneumonectomy.

12.2 Lobectomy

Currently, it is the standard form of therapy for most patients with lung cancer (Fig. 12.1) [3]. It is also performed for an infective pathology (post tubercular sequelae, lung abscess and fungal infections). It can be performed via open thoracotomy or VATS. Once the surgeon has dissected the lobe and blood vessels, the anesthesiologist is asked to perform a maneuver to confirm whether the surgeon has clamped the correct bronchus or not. The anesthesiologist unclamps the DLT or deflates the bronchial blocker and inflates the operative lung to see that the correct lobe has been clamped while the remaining lung gets ventilated. In addition, prior to division of any structure by surgeon, the anesthesiologist has to make sure that no object (endotracheal tube, suction catheter) is present at the site of surgical resection.

12.3 Sleeve Lobectomy

It is a parenchymal sparing surgery in patients with limited pulmonary reserve where otherwise a pneumonectomy is indicated. The diseased lobe is removed with sleeve of main stem bronchus and the remaining lobe with its bronchus is re-anastomosed with the proximal mainstem bronchus [7]. This is commonly performed in bronchogenic carcinomas, carcinoid tumors of bronchus, endobronchial metastasis, and bronchial adenomas. The surgery demands lung isolation to be done by using contralateral DLT so that it does not interfere with the surgical field.

12.4 Pneumonectomy

It is a high risk thoracic surgical procedure performed for large central tumors, distal main stem bronchus involvement, tumors with transfissural extension, advanced bronchiectasis and invasive infections with parenchymal destruction not responding to antibiotic therapy (Fig. 12.2) and a massive hemoptysis [8]. It is associated with higher incidence of complications (cardiac, acute lung injury (ALI), and ARDS) and mortality (8–10% vs 2% for lobectomy) [9].

It is traditionally performed via a posterolateral thoracotomy incision, but minimally invasive approaches are also gaining popularity. Here pulmonary artery, superior and inferior pulmonary veins, and main stem bronchus are evaluated for resectability, looped and divided. After dividing the bronchus, the test for air leak

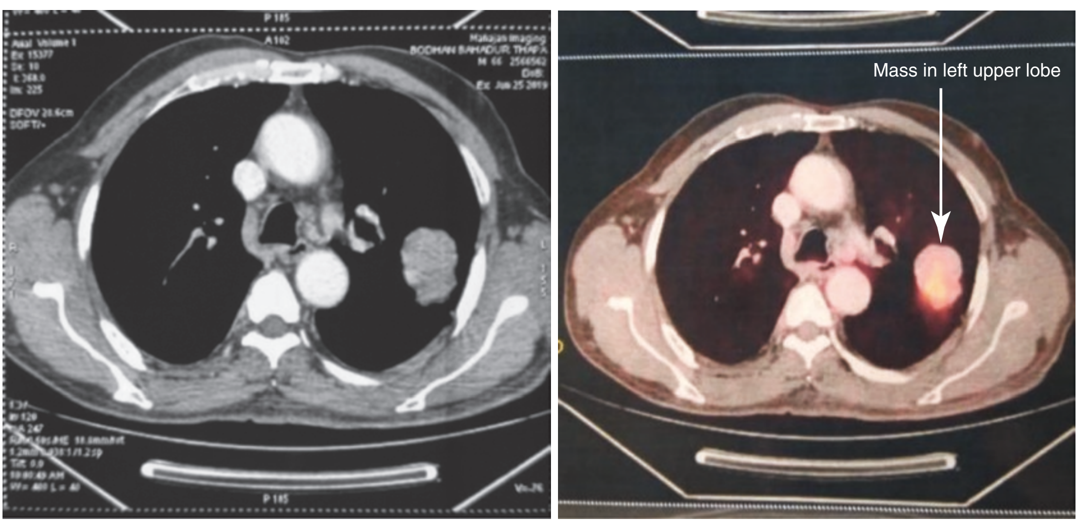


Fig. 12.1 Adenocarcinoma left upper lobe posted for left upper lobectomy

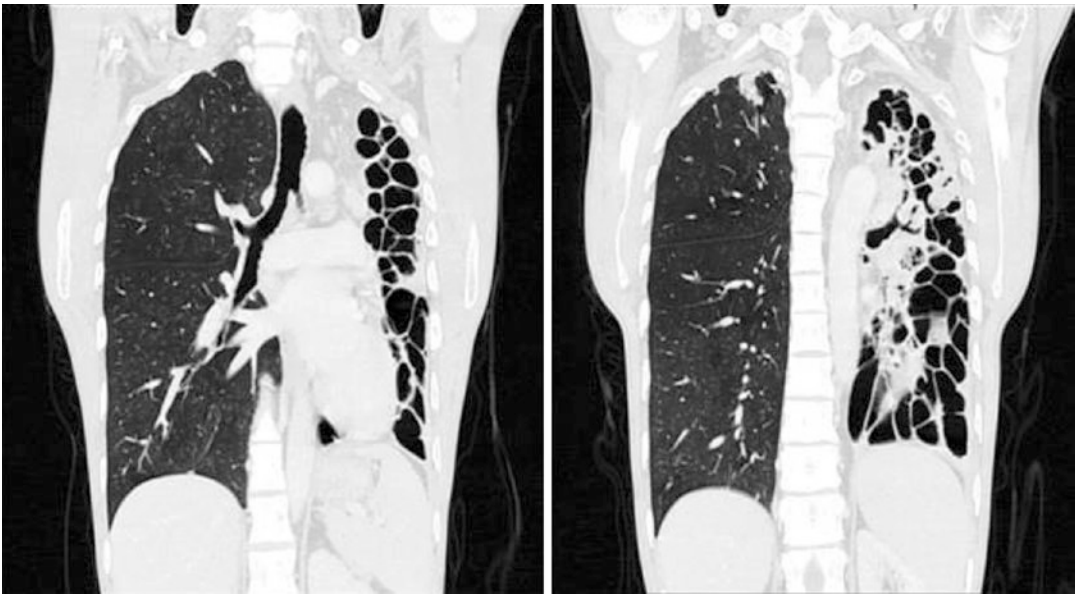


Fig. 12.2 CT image showing left-sided post tubercular destroyed lung requiring pneumonectomy

is performed and bronchial stump reconstruction done to prevent the formation of bronchopleural fistula. In these cases also the lung has to be isolated using contralateral DLT or if the same sided DLT is used, it is to be withdrawn before dividing the bronchus.

ALI (post-pneumonectomy pulmonary edema) is the most dreaded complication after pneumonectomy ultimately leading to respiratory failure. Incidence of ALI is up to 4–8% and is associated with upto 40%mortality [3]. Risk factors include right-sided pneumonectomy, increased perioperative fluid administration, decrease in ventilatory function, increase in pulmonary artery pressure and pulmonary vascular resistance and therefore an increase in RV afterload [10–12].

Focus should be on restrictive use of perioperative fluid therapy and protective lung ventilation strategies to decrease morbidity and mortality associated with pneumonectomy.

There is no standard consensus among surgeons for the best management of post pneumonectomy residual space. Immediately post surgery, some prefer to place an intercostal tube with continuous drainage while others prefer to clamp the same for 1–2 postoperative days.

12.5 Limited Pulmonary Resection (Segmentectomy and Wedge Resection)

Segmentectomy involves anatomical resection of a bronchopulmonary segment. This procedure is usually done in patients with smaller peripheral tumors with limited pulmonary reserves. Wedge resection is nonanatomical resection of a portion of lung parenchyma [13]. This is usually performed for diagnosis of lung nodules for frozen section or as a palliative procedure in patients with metastatic lesions.

12.6 Pleurodesis

This procedure involves fusion of parietal and visceral pleura causing obliteration of pleural space. Indications include recurrent pneumothorax, persistent pleural effusion, and pneumothorax with prolonged air leak. This could be done either by chemical pleurodesis using sclerosing agents such as talc, doxycycline or by mechanical pleurodesis by abrading the parietal pleura with a dry gauze or prolene mesh [2].

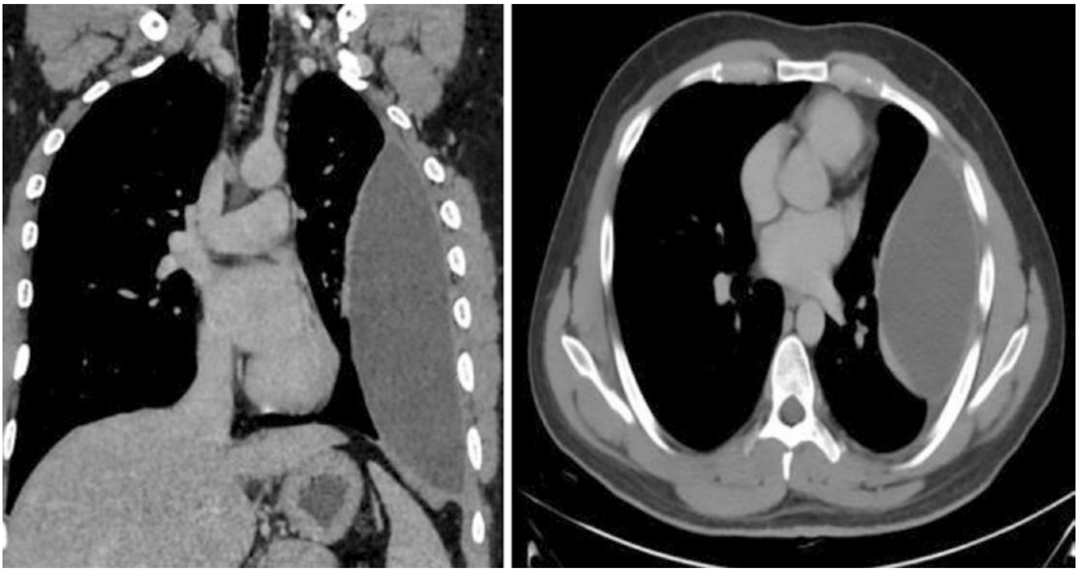


Fig. 12.3 CT image showing left-sided tubercular empyema compressing the left lung, necessitating decortication surgery

12.7 Debridement

This may be required in patients of empyema (Fig. 12.3) with tube thoracostomy not improving with antibiotics, multiloculated empyema and retained clots [2].

12.8 Decortication

It involves removal of fibrotic pleura (due to malignant, infectious or traumatic process) from the lung to allow expansion of lung. At the end of procedure, full re-expansion of the lung should happen to fill the pleural cavity to prevent any future recurrences. Common problems associated with this are lung injury and significant bleeding [2].

12.9 Urgency of Lung Resection Surgeries

In general, these surgeries are largely elective except for few situations where the risk of morbidity and mortality increases to a great extent.

Emergent procedures: Patients with massive hemoptysis where conservative and other modalities have failed.

Urgent procedures: In patients with lung abscess and bronchiectasis to provide source control when the patient is in severe sepsis.

Elective procedure: Lung carcinomas after proper preoperative evaluation and optimization done.

12.10 Preoperative Evaluation

The two main concerns to be addressed in preoperative evaluation include whether or not the patient will tolerate OLV intraoperatively and how will be the postoperative recovery profile [6]. Evaluation of the cardiopulmonary status is of paramount importance. Pulmonary function test and gas exchange are not indicated in every patient except in lung resections. The base line clinical status/functional capacity of the patient and the extent of the planned surgery guide the physicians for preoperative evaluation. All patients should be assessed according to the three-legged tool including: (1) respiratory mechanics, (2) pulmonary gas exchange, and (3) cardiopulmonary reserve (See Chap. 6).

All patients should be evaluated as per the AHA/ACC guidelines for patients with cardiac disease for noncardiac surgery, as thoracotomy/lung resection surgeries are considered high risk procedures for cardiac complications, > 5% [14].

Patients having active cardiac conditions should be evaluated and treated before undergoing any thoracic surgery. Patients who are with baseline decreased pulmonary function scheduled for extensive lung resection should undergo cardiopulmonary exercise stress testing to predict their ability to tolerate the surgery [15].

Following conditions require the patient to be evaluated and optimized before taking up for surgery [1]:

1. Decompensated heart failure
2. Severe valvular disease
3. Significant arrhythmias
4. Recent MI (< 30 days)
5. Unstable angina, COPD exacerbation
6. Active tracheobronchial/lung infection
7. Active infection/sepsis of any source
8. DVT and/or pulmonary embolism
9. AKI on CKD

12.11 Implications of Coexisting Diseases on Perioperative Care

A. Cardiovascular system

Incidence of perioperative MI during lung surgery is nearly 4%, which increases up to 20% in patients with previous MI [16]. If history and/or ECG suggests previous MI, the patient should be evaluated by exercise stress testing. If stress testing shows myocardial ischemia, this situation requires further evaluation by coronary angiography. Invasive procedures like PCI and CABG should be considered only if indicated, regardless of the planned lung resection surgery [17–21].

Lung resection surgeries should be deferred for at least 4–6 weeks post CABG and if percutaneous coronary intervention is required (PCI), bare metal stents should be implanted instead of drug eluting as then the patient can undergo surgery after 3 months [22]. In patients with increased risk of perioperative myocardial ischemia, maintain oxygen demand/supply by heart rate control, maintaining coronary perfusion pressure, preventing hypoxemia, and optimizing oxygen carrying capacity.

Beta blockers should be either continued in patients already taking them or should be started well before rather than immediate preoperative [23].

Pneumonectomy can significantly cause right ventricular dysfunction with immediate increase in right ventricular afterload after clamping the ipsilateral pulmonary artery. It is most pronounced on first postoperative day but may present later as well.

These changes can also be seen in lobectomy, but are generally well tolerated unless patient has baseline pulmonary hypertension [24].

B. Pulmonary system

Pulmonary complications are the major cause of morbidity and mortality in patients undergoing thoracic surgery:

Severity of pulmonary complications depends on various factors such as,

1. Baseline pulmonary function
2. Degree of lung tissue resected
3. Mechanics of chest wall (Thoracotomy/VATS)
4. Adequate postoperative analgesia

(i) COPD

Patients should be assessed for COPD/ILD and severity of its symptoms.

Risk reduction

Patients should be optimized before surgery with medical therapy. This includes treatment with bronchodilators, treatment of active airway infection by specific antibiotics and pre- and postoperative chest physiotherapy to prevent retention of secretions and atelectasis.

(ii) Bronchial Asthma

Optimization to achieve minimal airway reactivity and peak expiratory flow more than 80% of the patient's baseline. Short acting bronchodilators and corticosteroids should be continued until the day of surgery. In symptomatic patients a short course of oral prednisolone is effective.

(iii) Smoking

Risk of pulmonary complications associated with smoking is directly proportional to pack years and inversely proportional to time since last use. Ideally it should be stopped at least 8 weeks prior to surgery to reduce the complications, but even short-term cessation is beneficial than smoking up to the time of surgery, as it decreases the level of carboxy hemoglobin and thus there is less hypoxemia [25, 26].

C. Renal System

Patients undergoing thoracic surgery, especially pneumonectomy are at high risk of acute kidney injury [27]. Multiple risk factors include perioperative hemodynamic instability with hypotension and decreased renal perfusion pressure (Fig. 12.4), hypovolemia due to fluid restriction, peripheral vascular disease, diabetes mellitus, hypertension, large volume of colloids, lower hematocrit values, SIRS triggered by ALI and neuroendocrine/metabolic response to surgery [1].

Presence of preoperative CKD or pre- and peroperative risk factors for AKI can make these patients highly susceptible for developing perioperative AKI.

Risk reduction measures:

1. Maintain preoperative normovolemia in patients with high risk
2. Avoid acute on chronic anemia
3. Correct hypotension and vasodilatation by using vasopressors to maintain renal perfusion pressure
4. Avoid nephrotoxic drugs

D. Gastrointestinal system

Patients with GERD/hiatus hernia are assessed for severity of symptoms. LFTs and albumin are part of preoperative evaluation of cancer patients, who those with infective pathologies and are on ATT [1].

Risk reduction measures:

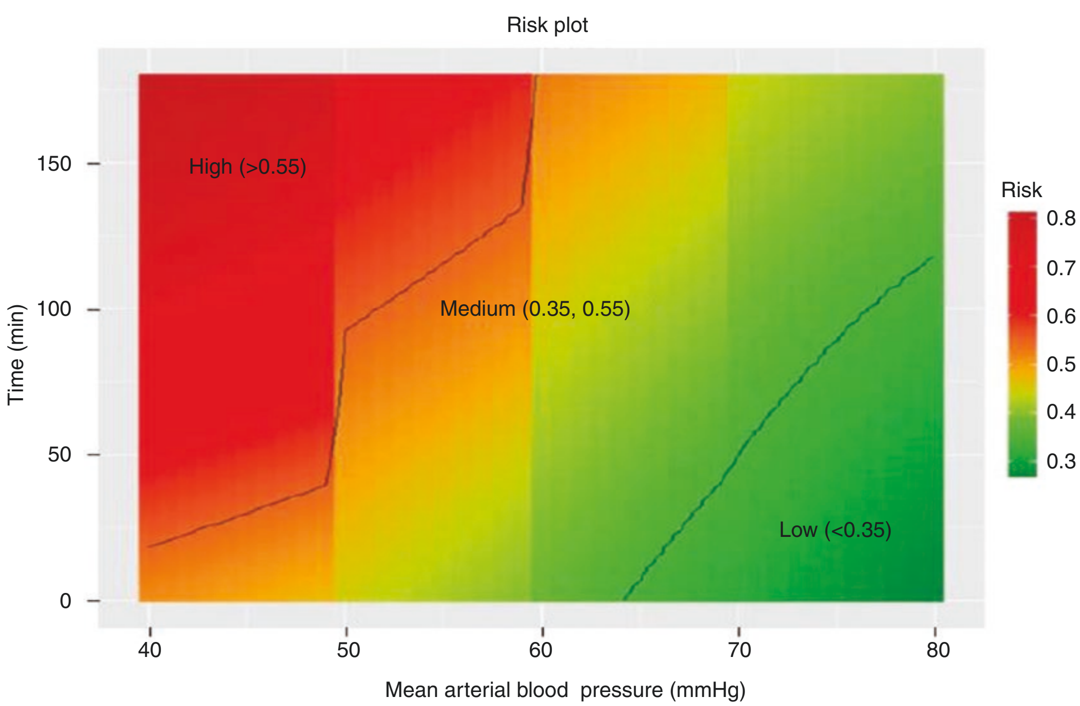


Fig. 12.4 Correlation between intraoperative blood pressure and risk of AKI

1. Consider giving H2 blockers and prokinetics in those with poorly controlled reflux symptoms
2. Titrate dosage of anesthetic medications in patients with hypoalbuminemia and malnutrition and expect longer duration action of medications in these patients

12.12 Preoperative Concerns Specific to Pleural Surgeries

1. Septicemia may be present in patients with empyema/BPF, so optimal antibiotic therapy should be started preoperatively.
2. Patients with infective pathologies or chylothorax may be malnourished and hypovolemic. So, preoperative TLC, serum electrolytes, total protein and albumin levels should be evaluated.
3. Decortication surgeries where significant blood loss is anticipated, blood and blood products should be arranged [2].

12.13 Intraoperative Management

The goal of any anesthetic technique for lung resection and pleural surgery is to provide earliest extubation with fast return of spontaneous ventilation and best possible respiratory mechanics with minimal alteration of sensorium.

12.14 Equipment Required

Equipment for lung isolation e.g. double lumen tube, bronchial blockers or univent tubes should be arranged. Fibreoptic bronchoscope to check tube placement and intraoperative use should be ready. Bougie and airway exchange catheter are desirable. A circuit for delivering CPAP bean bags, warming devices including warn air blankets and IV fluid warmers should all be available.

12.15 Monitoring

Once patient's identity is confirmed, consent obtained, and site marked, an IV line preferably 18G should be secured on the nondependent side

Fig. 12.5 Final lateral positioning of the patient showing IV access on nondependent limb and arterial line on dependent limb and cotton padding done

(Fig. 12.5). After induction of anesthesia, another 18 gauge IV line is secured. Blood loss is usually minimal except for surgery in patients, post radiotherapy, extra pleural pneumonectomy and decortication. If surgical dissection around great veins (vena cava/subclavian vein) is expected, then contralateral venous access, central line, or lower limb access should be taken.

An invasive arterial line should be put in the dependent limb usually after induction of anesthesia for beat-to-beat blood pressure and arterial blood gas monitoring (Fig. 12.5).

Central line insertion is routinely not required but may be indicated in patients with cardiac comorbidities, CKD, anticipated large volume blood loss, extensive pulmonary resections and patients requiring hyper alimentation in postoperative period.

Use of pulmonary artery catheter is not routinely recommended due to its unreliable measurements, but if used, care to should be taken to withdraw the catheter to the pulmonary valve before clamping and ligating the PA.

TEE is more sensitive than pulmonary artery catheter for monitoring intraoperative cardiac function and fluid administration. Urinary catheterization is done for urine output monitoring.

In lateral positioning, an axillary roll (Fig. 12.6) is placed under upper chest and not in the axilla to prevent brachial plexus injury and head is supported to avoid any traction on neck (Fig. 12.7). A cotton roll is placed between neck and shoulder joint to

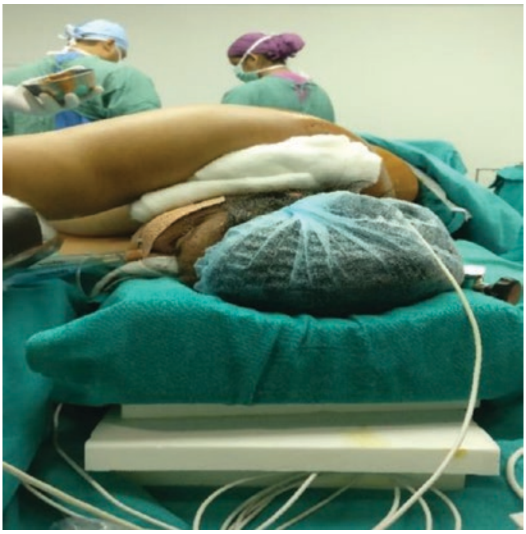


Fig. 12.6 Lateral positioning showing axillary roll kept under the upper chest

Fig. 12.7 Final positioning of patient showing head supported and cotton roll kept between neck and shoulder

prevent postoperative shoulder pain (Fig. 12.7). Cotton is placed under all bony prominences to prevent peripheral nerve injuries.

12.16 Anesthesia Technique

General anesthesia with preoperative insertion of thoracic epidural catheter for perioperative analgesia is technique of choice. However, at author's institute, the epidural is inserted post induction after counselling the patient.

Avoid preoperative use of sedatives, especially in patients with lung disease and limited respiratory reserve. Titrate the dose of induction agents, opioids, and neuromuscular blockers to ensure minimal respiratory dysfunction at end of procedure. Opioids to be used by epidural route preferably. Avoid use of epidural opioids less than 1 hour before end of procedure. Use short acting inhalational/intravenous agents for prompt extubation.

There is no proven benefit for use of intravenous versus inhalational agents for maintenance of anesthesia when either one is used with thoracic epidural. Short acting volatile agents decrease air way irritability, obtund air way reflexes and can be eliminated rapidly allowing early extubation, but should not be used in more than one MAC concentration as they prevent HPV.

12.17 Lung Isolation Techniques

Proper separation of lung ventilation requires placing a DLT or bronchial blockers. DLT allows rapid lung collapse and ventilation, allows suctioning and applying CPAP to operating lung which is not possible with a bronchial blockers. It is a practice at the author's institute to put DLT on contralateral side in surgeries involving main stem bronchus (for example pneumonectomy or main bronchus sleeve resections).

12.18 Ventilatory Settings

At author's institute, it is usual practice to ventilate the patient using pressure control mode as it is more physiological.

After confirmation of DLT placement, airway pressures on two-lung ventilation in lateral position are noted and then are seen again after clamping the operative side. The airway pressures should normally increase by up to 10 cm of water after clamping. If the increase is more than that, then suspect tube misplacement and reconfirm the position of the tube.

Pressure control ventilation for OLV is preferred as every patient has a different lung compliance. This mode gives breaths, which are almost similar to physiological breaths, the tidal volume varying with each breath and according to lung compliance, thus reducing lung damage due to pressure.

Hypoxemia and acute lung injury are the major concerns with OLV. Hypoxemia is usually due to alveolar hypoventilation and increased shunt fraction, whereas ALI is caused by ventilatory stress (volutrauma, barotrauma, atelectrauma), re-expansion pulmonary injury, massive transfusion and lung surgery itself. High intraoperative tidal volume (more than 6 ml/kg) is an independent risk factor for developing ALI following lung resection surgery especially pneumonectomy [28, 29]. Following pneumonectomy, FRC of the residual lung increases, so using larger tidal volumes combined with increased FRC could result in volume-induced lung injury.

Lung protective strategy includes tidal volume of 4–6 ml/kg ideal body weight with peak pressures of <35 cm water and plateau pressure of <25 cm water with respiratory rate adjusted to maintain normocapnia to mild permissive hypercapnia and PEEP as needed to improve oxygenation [30–32].

12.19 Ventilation in Special Situations

12.19.1 Obstructive Lung Disease

Besides the concerns discussed above, avoiding dynamic hyperinflation has to be taken care of in these patients. Dynamic hyperinflation occurs when there is inadequate expiratory time. This can be prevented using I:E ratio in the range of 1:3 to 1:5 and lower respiratory rates and avoiding extrinsic PEEP.

In patients with bullous emphysematous lung disease, where there is loss of structural integrity, using larger tidal volume or high airway pressures during OLV, will lead to complications like rupture, pneumothorax, and injury to non-bullous emphysematous lung as well. So, after completion of OLV, lung should be re-expanded with very low tidal volumes and airway pressures and gradually increasing them to achieve desired lung expansion.

12.19.2 Interstitial Lung Disease

ILD results in diffuse scarring and fibrosis of smaller airways and alveolar walls. It leads to increased elastic recoil of lungs with less distensible alveoli and contracted lung volume. High I:E ratio (1:1 or 1:2) with low tidal volume (around 4 ml/kg of predicted body weight) with high respiratory rates should be used to prevent increased airway pressures and its consequences.

12.20 Fluid Therapy

Perioperative fluid therapy in lung resection surgeries remains controversial. Reducing perioperative fluid administration and minimizing the hydrostatic pressure in pulmonary capillaries is of utmost importance in thoracic surgery in preventing ALI. A conservative fluid approach, i.e., zero balance is strongly suggested.

Restrictive fluid regime often warrants concomitant use of vasopressors to counteract the vasodilator effects of anesthesia and thoracic epidural blockade and to maintain renal perfusion pressure while maintaining intravascular normovolemia and stable hemodynamics [3].

Patients should be encouraged to take carbohydrate drinks up to 2 h before surgery. Intraoperative balanced crystalloids should be limited to 1–4 ml/kg/h to replace losses by perspiration, evaporation, and urine output. Replacement of third space losses is no more justified. Consider blood transfusion, to replace lost blood. Administer vasopressors to maintain hemodynamics rather than giving fluid boluses. Keeping the lung dry and circulatory compartments close to normovolemia remains a dictum in lung resection surgeries [33, 34].

Patients undergoing pneumonectomy have the highest possibility of developing right ventricular dysfunction. So, restricted fluid therapy has the utmost importance in preventing this complication. Pulmonary edema following pneumonectomy has a mortality rate of 20–40%.

12.21 Analgesia

Pain control is a significant goal to be achieved especially in patients with poor baseline lung function and with more extensive lung resections. Adequate postoperative analgesia helps decreasing respiratory complications.

Thoracic epidural (Fig. 12.8) is the mainstay technique used for providing intraoperative as well as postoperative analgesia. It is a common practice at author's institute to tunnel the epidural through the subcutaneous tissue before fixation to prevent its accidental removal while movement of the patient (Fig. 12.9). It can be used either as bolus technique, or patient controlled epidural analgesia (PCEA). Advantages include:

Fig. 12.8 Thoracic epidural placement

Fig. 12.9 Epidural tunneling done before fixation

1. Decreased incidence of cardiac arrhythmias
2. Early tracheal extubation
3. Decreased duration of ICU stay
4. Decreased intraoperative requirement of anesthetic drugs
5. Improved postoperative respiratory mechanics with better ability to cough
6. Early mobilization and chest physiotherapy
7. Suppression of neuroendocrine stress response [35–38]

12.22 Drawbacks

1. Technique related: dura puncture, spinal cord injury, hematoma
2. Hypotension
3. Bradycardia
4. Potential to decrease inspiratory effort with high level of motor blockade
5. Opioid-related nausea, vomiting, sedation, respiratory depression, pruritis and ileus

A combination of low concentration of local anesthetics and opioids is most commonly used. It is a common practice at author's institute to give epidural morphine in the intraoperative period followed by 0.0625% bupivacaine plus 2.5 mcg/ml fentanyl in postoperative period by PCEA pump. As nowadays, there is increased trend for minimally invasive surgical approaches, postoperative requirement for analgesia also decreases. Other techniques which can be used include thoracic paravertebral block, intercostal nerve blocks, and intrapleural analgesia [1].

12.23 Intraoperative Events

The following events are commonly encountered during lung resection and pleural surgeries:

1. During VATS procedure, surgeon generally uses CO_2 insufflation for collapsing the lung at a pressure approximately 6 mmHg which

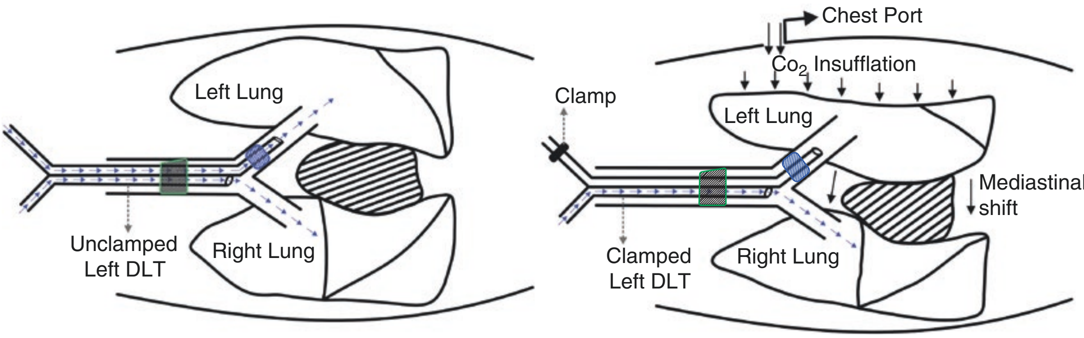
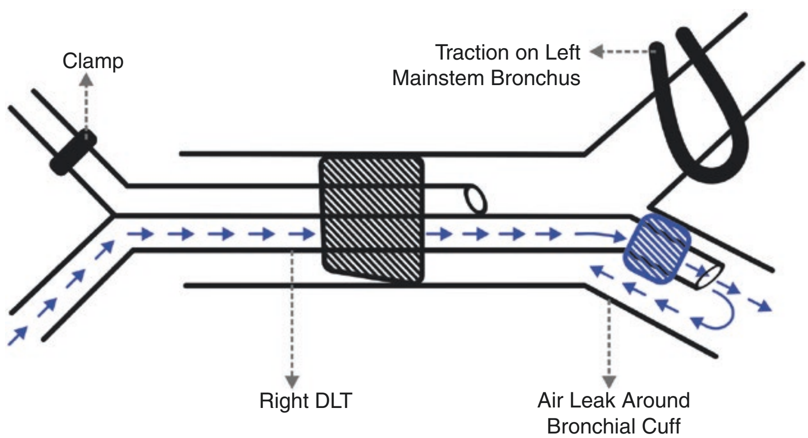


Fig. 12.10 Effect of CO_2 insufflation compressing the mediastinum and opposite lung

Fig. 12.11 Leak in ventilation when traction is put on the operative main stem bronchus



rarely may go up to 8 mmHg for 5–10 min. CO_2 insufflation causes the mediastinum to shift to contralateral side thus compressing the ventilated lung (Fig. 12.10) and decreasing the tidal volume delivery in PCV mode or increasing airway pressure if VCV is being used. So it is advisable to keep a watch on delivered tidal volume and titrate the settings accordingly.

2. During surgical dissection, when the surgeon loops the main stem bronchus in pneumonectomy, it pulls the endobronchial part of DLT in the contralateral bronchus thus causing leak in ventilation (Fig. 12.11). So a counter traction on the DLT should be maintained that time.
3. Before the surgeon divides the main stem bronchus and pulmonary artery, ensure that the DLT, suction catheter tip and PA catheter have been pulled back to make sure they are not included in the stapler line.
4. The anesthesiologist should be cautious, while the surgeon is performing hilar dissection or pericardial dissection as major vessel injury, arrhythmias, and hypotension can occur.
5. Once the lobe or lung has been removed, the surgeon tests for bronchial stump leak by asking the anesthesiologist to give sustained 25–30 cm of H_2O positive pressure in the circuit. The anesthesiologist should slowly expand the lung over 1–2 min starting with lower airway pressures and gradually increasing to prevent lung injury and chances of re-expansion pulmonary edema.
6. Hypotension is commonly encountered intraoperatively as there is decreased venous return due to surgical manipulation, superadded by hypovolemia and vasodilatation. It should not be treated with excessive fluid administration, rather use vasopressors and blood products if required.
7. During decortication more blood loss can occur as compared to lung resection surgery due to blunt dissection of pleura away from

chest wall. Patients with empyema or infective pathology may present with sepsis or sequelae.

8. In extrapleural pneumonectomy for malignant pleural mesothelioma, there is dissection of parietal pleura away from chest wall, diaphragm, and mediastinum followed by en-bloc resection of lung, pleura, pericardium and diaphragm [39]. This surgery involves more blood loss, major vessel injury, and cardiac complications. Manipulation during surgery can cause restriction to ventilation of the opposite lung leading to atelectasis.
9. Cardiac herniation can occur, when patient returns to supine position in patients who have undergone pneumonectomy and in patients where pericardium is partially removed and not reconstructed. It leads to kinking of great vessels and hemodynamic collapse which does not respond to chest compressions or pharmacological treatment. Immediate returning to lateral position or sternotomy should be done in such situations.
10. In patients undergoing surgery where the diseased lung was collapsed for quite some time, sudden re-expansion of that lung may lead to re-expansion pulmonary edema on the operating table. The anesthesiologist should be aware of this complication and expand the chronically collapsed lung very gradually.

12.24 Extubation

At the end of surgery, the patient should be completely awake with no residual neuromuscular blockade and optimal analgesia before extubation. Careful assessment of vocal cords should be done immediately after extubation in selected cases where there is suspicion of recurrent laryngeal nerve injury.

12.25 Conclusion

Patients undergoing lung resection and pleural surgeries are at high risk. Adequate precautions regarding intravenous fluids and ventilator strategies should be practiced.

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