General goals postoperatively:
1. Recovery from the specific physiologic changes and the general inflammatory response due to the surgical procedure
2. Decreased pain, early mobilization, and early return to normal function
3. Prevention and early detection of complications

It can not be overstated that excellent postoperative care begins with appropriate judgment regarding the preoperative risk assessment (preop risk assessment will not be discussed here, please see specific module regarding same). Overall perioperative mortality of thoracic surgical procedures ranges from less than 1% to 10%. This mortality is mainly caused by respiratory complications, such as atelectasis, pneumonia, and respiratory failure, which occurs in up to 15% to 20% of these patients. Cardiac complications occur in another 10% to 15%. This is why specific respiratory evaluation of both mechanics and gas exchange is performed in our standard preoperative assessments. This module discusses general postoperative care of patients undergoing major thoracic procedures. Additional considerations regarding specific operations can be found in respective modules.

PREOPERATIVE PREPARATION

Optimal postoperative care requires active cooperation and compliance of the patient. Preoperative education of the patient and family are key as well as providing written patient education materials (this is done in the office at the preoperative appointment). Smoking cessation is highly encouraged. Preparation for hospital procedures and advising the patient and family of potential complications and their warning signs should also be done. In particular, the use of various pain control techniques with appropriate/realistic expectations should be discussed. Preoperative pulmonary rehabilitation is more controversial. For high-risk individuals it may demonstrate changes in objective pulmonary function. This is definitely advisable for truly elective operations such as lung volume reduction surgery; however, it must be balanced against a risk of progression in patients with malignancy if surgical treatment is delayed.

Please note this module discusses general postoperative care of the non–mechanically ventilated patient

MONITORING

All patients who have undergone a major thoracic procedure must be cared for on a specialized postsurgical care unit. It is clear that optimal results emerge from units with significant experience. Our practice is to use an intermediate care unit with 1:2 nurse-to-patient ratio for all patients immediately after surgery unless postoperative ventilation is required. Patients who have undergone pulmonary
resection usually transfer to the step down floor on the first postoperative day, whereas esophagectomy patients usually spend their entire hospitalization in the intermediate care unit.

Monitoring of respiratory rate, heart rhythm, blood pressure, body temperature, urine output, and pulse oximetry are monitored continuously in the intermediate care unit, on the the step down floor they are measured intermittently, no less than every 8 hours. Measurement and calculation of fluid balance is very important in our patients. Some patients may need more invasive monitoring approaches, depending on their physiology and medical condition:

Arterial catheterization (radial artery) for:
- Constant blood pressure monitoring
- Ventilatory support/frequent abg’s
- Inotropic support
  (commonly used on our pts, most lobectomies and all esophagectomies)
Central venous catheter (subclavian vein or IJ) for:
- Central venous pressure as a basic measurement of volume status if necessary
- Infusion of inotropic support
  (infrequently used on our pts)
Pulmonary artery catheter (via introducer subclavian or IJ) for:
- Patients with inaccurate central venous pressure measurement
- Necessity of monitoring cardiac output
  (very rarely used on our pts)

Cardiopulmonary monitoring is essential especially during the initial few postoperative days because the majority of both cardiac and respiratory complications occur in the first 3 days. Atrial fibrillation and SVT are the most common arrhythmias. We use telemetry throughout the hospitalization.
Postoperative MI occurs in about 3% of patients. Symptoms of myocardial infarction may be more difficult to recognize due to analgesic effects, intubation, or other complications with similar symptoms. Half present with signs or symptoms suspicious for myocardial infarction, but only approximately 15% will complain of chest pain therefore level of suspicion must be high.

Majority if not all of our patients will have preoperative baseline ABG’s. This is helpful to identify those with carbon dioxide retention and hypoxemic respiratory drive. In these patients, an arterial catheter may be placed in the operating room. If an arterial line is placed it will be left in place for at least the first postoperative night and possibly for several days to monitor BP and trends in Paco2.

Standard postoperative blood tests include complete blood count, BMP, and magnesium. These are probably required only for the first 1 or 2 days after routine surgery. More complex procedures, such as esophagectomy, require more prolonged monitoring of blood tests. CXR’s are obtained daily on the majority of our patients, there are exceptions however that is procedure and patient specific which is beyond the scope of this module.
MAINTENANCE OF NORMOTHERMIA

Maintenance of normothermia during surgical procedures is important. Patients can develop hypothermia because of multiple factors, including exposure, evaporative loss, and peripheral vasodilation caused by general anesthesia. Hypothermia has various impacts, including metabolic, cardiovascular, endocrine, renal, hematologic, gastrointestinal, immunologic, neurologic, and pharmacologic effects. It contributes to coagulopathy, hypovolemia, insulin resistance, electrolyte imbalances, and increased risk of surgical site infection. It activates the sympathetic nervous system, leading to myocardial ischemia and increased risk of death. To keep patients warm, warming systems are used routinely, and ambient temperature can be rapidly adjusted. Measuring and maintaining body temperature is an essential part of postoperative care as well. Hypothermia is less problematic because patients can be more completely covered and fluid intake is decreased. Hyperthermia is common in the postoperative setting and can result in an increased metabolic rate and increased insensible fluid losses. Most fevers in the immediate postoperative setting are inflammatory in nature. Fevers that persist beyond the third postoperative day are suspicious for infection and call for further evaluation. Mild hyperthermia is tolerable, but significant temperature elevation must be treated.

INTRAVENOUS FLUIDS

The goals of intravenous (IV) fluid replacement are to correct deficits, to cover basal requirements, and to replace ongoing losses. Pulmonary, thymic, or benign esophageal surgery is not associated with large postoperative fluid shifts, but losses after esophageal, chest wall, or spinal resection procedures can be substantial. Lung manipulation and collapse impairs pulmonary lymphatic drainage and increases extravascular lung water due to disruption of the alveolar-capillary membrane. Because of this, patients undergoing pulmonary resections should not receive excessive fluid replacement, and standard fluid management used in other types of surgical patients needs to be moderated. Excessive fluids can result in pulmonary edema, decreased alveolar gas permeability, decreased pulmonary compliance, atelectasis, and hypoxia. On the other hand, esophagectomy patients may require large amounts of perioperative fluid, due to large third-space accumulation.

An adult should receive not less than 1000 mL of fluids per day. The minimal diuresis expected in a patient with normal renal function is 0.5 mL/kg/hr. It is necessary to remember that, in patients with renal failure and in those who have had large blood losses or fluid resuscitation, close monitoring of serum electrolytes, blood urea nitrogen, and creatinine is necessary. In special circumstances, such as after pneumonectomy, more extreme fluid restriction (<1.5 L) is followed. Attention needs to be given to how much fluid is provided with medications. Urine output and serum creatinine must be monitored and medications need to be reviewed to reduce or eliminate nephrotoxins, such as nonsteroidal anti-inflammatory agents (NSAIDs) or angiotensin-converting enzyme inhibitors.
POSTOPERATIVE NUTRITION

Enteral support may be started in the first 12 hours after surgery, but hemodynamic stability must be achieved first, to avoid intestinal ischemia. Most patients tolerate inadequate postoperative nutrition for a week, so the routine use of parenteral nutrition in thoracic surgical patients is uncommon. In esophageal resections, jejunal feeding tubes are inserted and can be used almost immediately however our protocol starts trickle feeds on POD2. Laxatives and stool softeners should be started on POD #1 if not started the evening of surgery as constipation is a common cause of readmission to hospital. Reduction in narcotics as tolerated, adequate oral hydration, and early ambulation all help.

RESPIRATORY CARE

Incentive spirometry is standard as is chest physiotherapy. Oxygen is administered as needed during the postoperative period. Many patients with hypoxemia benefit more from physiotherapy to increase functional residual capacity than from further increases in Fio2. If necessary, supplemental oxygen is administered by nasal cannulae, with the lowest flow possible to sustain oxygenation saturation greater than 92%. Excessive oxygen administration has potential drawbacks despite the short-term margin of safety it can provide. Increased alveolar oxygen tension promotes atelectasis as the oxygen is rapidly absorbed. Drying of secretions, even by humidified gases, can increase difficulty with coughing and clearance of mucus. Patients with chronic obstructive pulmonary disease (COPD) may have chronic carbon dioxide retention and a hypoxic respiratory drive. Removal of their chronic hypoxemia can lead to respiratory depression and progressive carbon dioxide retention, with subsequent respiratory acidosis. Therefore, in patients who have an elevated Paco2 preoperatively, oxygen saturation is maintained at 90% or less, preserving the hypoxic drive to breathe. There is little if any data regarding the use of noninvasive ventilation or CPAP after general thoracic surgery. Bedside bronchoscopy can be used on the step down floor to clear secretions if necessary when cough is ineffective.

DRAINAGE OF THE PLEURAL CAVITY

The goal of a pleural drainage is to evacuate the accumulated substance (liquid and/or air) and to promote lung re-expansion. Chest tubes are removed once there is minimal drainage, the air leak has stopped, and the lung is felt to be completely expanded. (Minimal drainage definition varies from attending to attending as well as patient to patient depending on clinical scenario, it may even vary from day to day on the same patient- always ask attending prior to removal of chest tubes if removal is appropriate) The chest tube is removed quickly during a Valsalva maneuver at the end of expiration. Our current approach with regards to suction with chest tubes is to begin at -20cm suction coming out of the operating room and then stepping down to water seal in a fashion dictated by the specific procedure which is beyond the scope of this module. (please see pathways for specifics) There are several approaches to management of a prolonged air leak. If pleural apposition is not achievable, minimal or no suction and patience are important. Heimlich valves/Pneumostats can be used to discharge patients who still have a minimal air leak without any other medical complication. If
this approach is not feasible, reoperation may be required. Identification and/or correction of an air
leak at thoracoscopy is not particularly easy. If pleural apposition is not achievable in the face of an
ongoing air leak, a computed tomographic (CT) scan is often helpful to indicate remaining pockets where
intrapleural air is preventing the lung from touching the ribs. This can guide placement of additional
chest drains. Once full pleural apposition is achieved, the air leak may immediately cease. If not,
pleurodesis may be achieved by instillation of agents to inflame the pleura, such as doxycycline, the
patient's own blood (IV drawn), or talc. Finally, if the leak persists for more than 10 days, the suction can
be gradually reduced with CXR monitoring of the chest. If the lung remains inflated, the chest tube can
be converted to water seal and even subsequently clamped, despite an ongoing air leak. Occasionally, a
loculated pneumothorax results, but, as long as it is stable over several days, the patient may be
discharged, and the space usually resolves gradually over the next few weeks.

**MEDICATIONS**

**Prophylactic antibiotics can diminish the risk of infection, our practice is to only give intraoperative**
**prophylaxis to lung resection patients** (an effort to decrease total volume of fluids given to these pts
**and no evidence supporting continuing beyond this**) **but we do continue antibiotics for the first 24**
**hours routinely on the esophagectomy patients. Duration of periop antibiotics in other patients is**
**dictated by the particulars of the patient and/or case.** With most medications, patients can and should
**resume their preoperative regimens as soon as possible. Patients with hypothyroidism can develop**
**bradycardia, systemic hypertension, narrow pulse pressure, reduced cardiac output, angina, and an**
**abnormal ECG and are at risk for other postoperative cardiac events, such as ventricular arrythmias.**
**Patients who are currently taking thyroid hormone replacements should restart them as soon as oral**
**intake is re-established. Patients with preexisting peptic ulcer disease require resumption of their**
**previous medications. Patients with diabetes may need to be covered with insulin while in hospital as**
**many oral diabetes medications are not appropriate in the immediate postoperative time period.**

**PAIN CONTROL**

Pain and the immobility it causes result in decreased cough and clearance of secretions thus leading to
an inability to recruit alveoli. Atelectasis and hypoxemia develop, increasing the risk of pneumonia. It
must also be stated that results of surgery are affected by other factors, such as avoidance of undue
sedation to ensure good cough, adequate blood pressure to ensure adequate tissue perfusion pressure
at healing anastomoses, and quick return of normal bowel function. Therefore, postoperative pain
needs to be optimally controlled while keeping these other goals in mind.

**Our standard pain regimen begins intra operatively with intercostal blocks using long-acting**
**bupivacaine with epi (which delays absorption). Postop we have scheduled IV Tylenol for 3 doses**
**transitioning to scheduled oral dosing, and we also schedule oxycodone 10mg every 4 hours to start in**
**PACU thus allowing adequate analgesia being in board as the intercostal blocks inevitable wear off.**
**This can be adjusted for particular patient characteristics if necessary but this regimen is the preferred**
**regimen of our surgeons.**
PREVENTION OF CARDIAC ARRHYTHMIAS

Atrial tachyarrhythmias, predominantly atrial fibrillation, are the most common cardiac complications after general thoracic surgical procedures. Atrial fibrillation can lead to palpitations, fatigue, hypotension, congestive heart failure, angina or infarction, stroke, prolonged hospitalization, and increased costs. Blocking of β-adrenergic receptors is important in the prevention of atrial fibrillation because reducing the sympathetic tone reduces the susceptibility to postoperative dysrhythmias. Agents with β-blocking effect are effective, with a reduction to less than half the normal incidence of atrial fibrillation. In majority of our patients, β-Blockers are started 1 week before surgery and continued during the entire hospitalization for lobectomy and esophagectomy cases, we do not routinely continue β-Blockers if we perform only a wedge or segmental resection (unless the patient was on these medications for another reason preoperatively and then we continue their home regimen).

PREVENTION OF DEEP VENOUS THROMBOSIS AND PULMONARY THROMBOEMBOLISM

All our patients are at moderate risk. In all patients, apply elastic compression stockings before surgery, and patients need to resume walking as early as possible after surgery, usually the same day or the next morning at the latest. For prophylaxis enoxaparin is preferable in cancer patients (unless wgt is low and prophylactic dose is close to a therapeutic dosage or they have underlying renal dysfunction) and heparin is utilized in all other cases (we order prophylaxis to start the morning of POD #1). Patients taking anticoagulants before surgery ask the surgeon when we will resume anticoagulation. In general with standard evidence based protocol we can resume IV heparin, without bolus infusion, 6 to 12 hours after surgery, depending on intraoperative blood loss and the urgency for anticoagulation. Low-risk patients, such as those with atrial fibrillation without prior stroke or cardiomyopathy without atrial fibrillation, can resume anticoagulation after or at time of hospital discharge. Moderate-risk patients with a mechanical aortic valve must be restarted on anticoagulation therapy before discharge. High-risk patients (e.g., mechanical mitral valve, atrial fibrillation with prior stroke) must be anticoagulated with IV heparin as soon as possible after surgery. This all being said, the timing of resumption of home anticoagulation will be determined by the patient’s surgeon.

NEUROLOGIC ISSUES

Many thoracic surgical patients have risk factors for postoperative delirium. The incidence is approximately 10% and is more common after esophagectomy. Data identifies age greater than 70, alcohol abuse, poor cognitive status, poor functional status, and markedly abnormal preoperative sodium, potassium, or glucose level as risk factors. Noncardiac thoracic surgery is itself a risk factor. Patients with delirium tend to have more major complications, longer lengths of stay, and less chance of discharge directly to their homes.