**Chapter title:**

**Physiotherapy Management for Thoracic surgeries**

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**INTRODUCTION**

The overall success of thoracic surgery is not measured by its technical success alone. Rather, surgical success is based on the

* Individual`s complete return to full participation in the life and the capacity to perform its requisite activities.
* Avoidance of recurrence of the problem for which the individual’s surgery was indicated, reduced subsequent doctor- and hospital-based care.
* lifelong health.

In patients who undergo thoracic surgery, physiotherapy has played a significant part in minimizing the adverse effects of anesthesia and surgery on the respiratory system for more than 50 years. Physiotherapy interventions have been regularly utilized in the prevention and treatment of both pulmonary and musculoskeletal complications following major surgery since the 1960s.

This role of the physiotherapist has been supported by evidence from clinical trials reported since 1947 demonstrating the postoperative prophylactic physiotherapy for the prevention of PPCs and musculoskeletal problems ensuing. The evidence advocated pre-and postoperative physiotherapy and thereby reducing patient morbidity and prolonged hospital admission.

Following thoracotomy, pneumonectomy, Lobectomy, etc. Postoperative pulmonary complications (PPCs) are an important cause of morbidity, contributing to significant increases in health care costs, length of intensive care, and hospital sta,y and patient discomfort. The physiotherapy treatment during the hospital stay generally consists of early mobilization, range of motion exercises, and breathing exercises

The physical therapist is involved at all stages of preoperative care as indicated and has a primary role in identifying individuals at risk of perioperative complications and preventing those complications as well as in ensuring true surgical success as defined above.

The patient’s condition is one factor that can determine perioperative risk, operative course, and long-term outcomes. Physical therapy prevents complications and addresses oxygen transport threats and deficits. In the long-term, physical therapy helps ensure the individual returns to normal life and regains or surpasses premorbid presurgical functional status.

**INDICATIONS**

* **BRONCHIECTASIS:**

The extent of the bronchiectasis must be assessed by complete bronchograms of both lungs so that the segmental involvement can be accurately defined. Surgical treatment should excise all the affected segments or lobes, and it is therefore essential that the disease is well localized and not scattered throughout both lungs. Removal of the affected area may be by pneumonectomy, lobectomy, or segmental resection. if pneumonectomy is contemplated the contralateral lung must be normal. Bilateral lobectomy or segmental resection may also be undertaken. In patients with bilateral disease,resection is contraindicated if more than seven to eight segments are involved.

* **BENIGN TUMOURS:**

Benign tumors such as carcinoid or hamartoma may be treated by local bronchial resection or enucleation unless they occlude a bronchus and cause distal infection or bronchiectasis, in which case a lobectomy or pneumonectomy will be necessary.

* **CARCINOMA:**

90% of lung resections are carried out for carcinoma. Resection is the treatment of choice for this disease, including small cell carcinoma provided that: The patient is fit enough to undergo operation; There is no evidence of spread of the growth outside the chest; There is no clinical or investigatory evidence of inoperability.

Resection of carcinoma may be by standard pneumonectomy (simple extrapericardial), extended pneumonectomy (radical intrapericardial), lobectomy, or segmental resection. Pneumonectomy might seem to be the only logical operation for carcinoma of the lung but as many of these patients also have chronic bronchitis this operation is often unfortunately very disabling and many are never able to resume work, especially if they are over the age of 55 years. Because of this, lobectomy and, much less often, segmental resection are both carried out and both have provided excellent results in terms of cure rate as well as the quality of life. Lobectomy for peripheral carcinomas is as effective in curing the patient as pneumonectomy and carries lower operative mortality.

* **Secondary carcinoma:**

Secondary deposits in the lung from carcinoma and sarcoma occur frequently. They are usually multiple but may occur singly; if so, they should be excised, provided there is no evidence of any other metastases and the primary tumor has been treated two or more years previously.

* **Chronic infection :**

If the infection cannot be controlled by prolonged courses of an appropriate antibiotic, a lobectomy or even pneumonectomy, will be necessary. In these cases, hilar dissection is likely to be very difficult and this may make a more limited resection impossible.

* **Empyema :**

Empyema is a collection of pus in the pleural cavity. The cause is commonly pneumonia, lung carcinoma or abscess, bronchiectasis, or more rarely TB. It can occur in patients with septicemia or osteomyelitis of the spine or ribs.

* **Tuberculosis :**

Modern antituberculosis drugs have revolutionized the treatment of tuberculous but operation may still be required in patients who have developed drug resistance, who continue to be sputum-positive, or who have non-tuberculous infection distal to branch stenosis. The assessment of these patients for surgery is often very difficult and the indications for the operation are controversial.

* **Pneumothorax:**

This is a collection of air in the pleural cavity. It usually occurs spontaneously and is due to a rupture of the visceral pleura of an otherwise healthy lung. Pneumothorax is more common in men than women and more usual in the under-forties.

**THORACIC INCISIONS**

**POSTEROLATERAL THORACOTOMY/ MUSCLE-SPARING POSTEROLATERAL THORACOTOMY:**

The postero-lateral thoracotomy is one of the most frequently used incisions in thoracic surgery. Most pulmonary resections are performed through this incision, and it also provides excellent access to the mediastinum for resection of mediastinal masses. Certain open and closed cardiac procedures, such as coarctation repair, aneurysm resection, and mitral valve replacement, may also be performed through this incision.

The patient is placed in a true lateral position on the operating table. the skin incision extends from just below the nipple posteriorly to 1 inch below the tip of the scapula and then extends upward between the scapula and the spine. Subcutaneous tissues are divided along the course of the incision, as are the latissimus dorsi and the serratus anterior.

Once the muscles are divided the shoulder girdle will glide upward, allowing the scapula to retract away from the intended intercostal incision. The proper interspace may be found by counting ribs from above downward. operations such as pulmonary resection are best done through the fifth intercostal space, whereas procedures such as ligation of patent ductus arterisus and co-arctation repair are performed through the fourth intercostal space. The first step in the closure of the incision is the placement of chest tubes within the thoracic cavity. A chest tube is placed anteriorly principally for evacuation of air, and a second tube is placed posteriorly for the drainage of fluid and blood.

**LATERAL (MUSCLE-SPARING) THORACOTOMY:**

This approach is the universal thoracotomy, which provides excellent exposure including extended procedures such as sleeve resections of the bronchi or intrapericardial pneumonectomy. It is an excellent thoracic incision for single lung transplantation. The skin incision is made on a horizontal line passing below the tip of the scapula to the submammary fold, the other is a landmark for the cartilage of the 6th rib. In the case of a standard lobectomy, the incision would be between 12 and 15 cm long, according to the patient's adiposity. In obese patients, the incision is extended anteriorly through the submammary fold. For bulky tumors or carinal approach, the incision is carried further to the back, behind the tip of the scapula. The subcutaneous tissue is divided until the fasciae are overlying the latissimus dorsi muscle and anterior serratus muscle.

**POSTERIOR THORACOTOMY:**

Before the development of lung isolation, pneumonectomy for the suppurative disease was often performed from a posterior approach. This permitted the early division of the bronchus and lung collapse. With the bronchus controlled, purulent secretions would not escape from the ipsilateral lung and contaminate the other side. Few indications remain for this approach.

The patient is placed in a prone position on a specially designed table that allows anterior access to the chest if necessary. An incision is extended from the anterior axillary line to the base of the neck, midway between the posterior edge of the scapula and the spine. Rhomboid, trapezius, latissimus, and serratus muscles are divided. The selected interspace may then be entered.

**THORACOABDOMINAL INCISION :**

The thoracoabdominal incision permits simultaneous dissection in pleural and abdominal cavities. The left-sided approach is particularly attractive for esophageal surgeons. This exposure facilitates esophageal, gastric, splenic, and retroperitoneal surgeries. The closure can be formidable and time-consuming. Postoperative recovery has been greatly improved because of epidural analgesia. Left lung isolation is necessary.

The patient is placed in a lateral position with the hips rotated back toward the operating table by 10 to 20 degrees. The sterile field includes the left arm and neck if a cervical esophagogastric anastomosis is anticipated. In cases of esophageal malignancy, the abdominal portion of the incision is made first to determine operability. An oblique incision from the midline to the left costal margin is utilized.

**MEDIAN STERNOTOMY:**

The median sternotomy is now utilized for the majority of cardiac operations as well as for other procedures, including thymectomy and resection of mediastinal tumors. The sternotomy incision is popular for cardiac procedures primarily because of the excellent exposure it provides for all parts of the heart. In addition, it offers several advantages for pulmonary resection. It is easily and quickly performed and thus shortens operating time. in the supine position, the incision is made with the scalpel from just beneath the suprasternal notch to a point between the xiphoid and umbilicus.

Once the sternum is divided a sterna retractor with broad blades is then carefully positioned and opened slowly. once the operative procedure has been completed, one or more large chest tubes are placed and led out through stab incisions at the lower end of the incision. The sternum is approximated with five to eight heavy stainless steel wires. Postoperative sternal wound complications constitute the other major problem with sternotomy incisions. Wound problems include sterile serosanguineous drainage, unstable sternum, sternal dehiscence, superficial wound infection, and mediastinitis.

**TRANSSTERNAL BILATERAL THORACOTOMY**:

This incision provides good exposure to the heart and anterior mediastinum. Anterior thoracotomy has both general thoracic and cardiac surgical applications. The right middle lobe is easily approached anteriorly, and bilateral anterior thoracotomy is gaining popularity for double-lung transplantation It was frequently used in the earlier years of cardiac surgery but has largely been abandoned because it is more time-consuming and more painful and results in more postoperative discomfort and pulmonary problems. Because a transverse skin incision is used, the resulting scar may be more acceptable for females.

The patient is positioned and the skin prepared and draped just as for a median sternotomy. A bilateral submammary incision is made extending from the anterior axillary line on each side and crossing the sternum at the level of the fourth interspace. The pectoralis muscles are divided with the scalpel or electrocautery, as are the intercostals muscles in the fourth interspace, and the left and right pleural cavities are entered.

The left and right internal mammary arteries and veins are carefully identified, ligated, and divided. The sternum may be divided with an electric saw. Appropriate retractors are inserted, and the incision is opened. After the operative procedure has been completed, intercostal chest tubes are placed in each pleural space.

**THORACOSTERNOTOMY (CLAMSHELL) INCISION:**

The clamshell incision offers superior exposure to the heart, great vessels, mediastinum, and pulmonary hila. It has applications in the management of life-threatening traumatic injury, pulmonary metastasectomy, and bilateral sequential double-lung transplantation. Rarely, the incision has been used for coronary surgery.

**Axillary Thoracotomy:**

This incision provides very satisfactory exposure for the first rib resection, thoracic sympathectomy, and limited procedures within the thoracic cavity. It requires the division of the intercostals muscles only, without division of the major chest wall muscles, and is also small, hidden, and therefore cosmetically appealing. The patient is placed in the lateral position with the chest rotated posteriorly approximately 20 degrees and supported with sand bags.

A transverse incision is made in the axilla at the point where the skin breaks from the chest wall. A slightly upward curved incision at each end is made from the pectoralis major anteriorly to the latissimus dorsi posteriorly. the dissection is extended to the chest wall, and the lateral thoracic artery and thoracoepigastric vein are divided as they are encountered.

**SURGERIES OF THORAX**

Surgical anatomy includes a thorough knowledge of bronchopulmonary segments and pulmonary vasculature. The following anatomical points must be borne in mind when resecting the lung.

* The origin of the right upper lobe is very close to the carina. Indeed, at bronchoscopy, the right upper lobe orifice and the carina appear to be almost the same distance from the upper jaw
* The middle lobe and the apical segment of the right lower lobe arise from the intermediate bronchus immediately opposite each other. This is of importance in right lower lobectomy
* The middle lobe vein drains into the right superior vein and when performing a right upper lobectomy it is most important to preserve this vein.

**Surgical Approach** *-* A posterolateral thoracotomy through the bed of the fifth rib provides the best exposure for all lung resections and allows the hilum to be approached from both front and behind.

**Sequence Of Dissection** *–* In all cases of resection for carcinoma it is advisable first to divide the vein draining the affected lobe to prevent tumor embolization during manipulation of the lung. Thereafter it does not matter in which order the hilar structures are divided, though if there is an excessive amount of sputum or hemoptysis it is preferable at least to clamp, if not divide, the bronchus first.

**Division of the main pulmonary artery and veins** *-* The dissection and control of the pulmonary vessels during lung resection is often very difficult, mainly because both arteries and veins are very fragile and tear easily. The O’Shaughnessy right-angled clamps are suitably rounded at their ends and very useful and safe instruments for the hilar dissection.

**Closure of bronchus-**A long bronchial stump is an important contributing factor in the formation of a bronchopleural fistula. It must therefore be avoided and the bronchus divided close to the trachea or adjacent lobar bronchus.

**ASSESSMENT:**

**PREOPERATIVE PERIOD :**

The preoperative assessment of patients undergoing lung resection is vitally important. Unfortunately, there are no definite standards to establish whether a patient is sufficiently fit to tolerate an operation and many factors must be taken into account. For example, whereas an obese bronchitic middle-aged patient may not survive a lung resection, a relatively thin man of 75 years or more tolerate the procedure very well not bronchitic. The clinical assessment must take into account the following:

1. **Chronic bronchitis**- A long history of bronchitis always indicates a greatly increased risk for a patient undergoing lung resection, whether a lobectomy or pneumonectomy. Even if he survives the operation he may be left a respiratory cripple, especially after a pneumonectomy
2. **Bronchospasm**- This also indicates a greatly increased risk, though to some extent it may be controlled by antispasmodic drugs and steroids. However, patients with significant bronchospasm will usually not tolerate lung resection. In a few patients, the bronchospasm may be associated with the lesion for which operation is required( e.g. unilateral due to benign bronchial tumor or bilateral bronchospasm so often associated with chronic bronchitis.
3. **Clinical examination** – The chest movements and configuration of the chest must be assessed by clinical examination. Patients with a ‘barrel–shaped’ chest large anteroposterior diameter) often suffer from chronic bronchitis and emphysema, and this will be confirmed by the radiological absence of lung markings and a depressed diaphragm. Excessive obesity also increases the operative risk.
4. **Lung function studies**- It is customary to undertake extensive lung function studies in patients considered for lung resection. However, although these tests provide valuable confirmatory evidence of impaired lung function, they are often very difficult to interpret and do not replace the simple tests of asking the patient how short of breath he is on exercise and walking with him up two flights of stairs.

**PREPARATION OF THE PATIENT**

This is of vital importance and 2-3 days of intensive preoperative treatment will often shorten the patient's stay in hospital by 2-3 weeks- and may even be life-saving. the aims of the treatment are:

* Reduction in bronchial infection by the appropriate antibiotic and postural drainage if necessary ;
* Reduction of bronchospasm by antispasmodic drugs such as ephedrine or salbutamol, together with steroids if necessary
* Correction of anemia and
* Instruction in deep breathing exercises by the physiotherapist.

**PREOPERATIVE PHYSIOTHERAPY ASSESSMENT**

Once the appropriate patients have been identified, further questioning may be necessary concerning the patient's smoking and respiratory history including any relevant medications such as bronchodilators or steroids. It is important to establish the patient's exercise tolerance and to undertake a general examination of the musculoskeletal system. Examination of the chest should also be carried out.

**TEACHING AND INFORMATION**

Considering the amount of verbal information given to the patient at this stage, details should be brief and concise and ideally, backup written material should be provided. Preoperative explanation regarding the effects of surgery on respiratory function, the location of the wound, drips, and drains may help to reduce pain, Quicken recovery after the operation. It has been reported that 75% of patients who participated in a pre-admission education program for patients undergoing cardiac surgery felt a resultant reduction in anxiety levels in response to the information that they received. The physiotherapist should also stress the importance of early mobilization, appropriate positioning while chairing or bedbound, adequate pain control, regular thoracic expansion Exercises, and wound support during huffing or coughing if bronchial secretions are present. Close liaison with the nursing staff and provision of information leaflets will help to emphasize the importance of these activities to the patient.

**Objectives of the preoperative physical therapy assessment and teaching**:

* Develop rapport with the patient
* Assess cognitive status, capacity to cooperate, language and communication skills, and cultural and ethnic beliefs and attitudes toward surgery and care
* Assess the patient and estimate the degree of surgical risk(e.g., age, smoking, previous cardiopulmonary dysfunction, neuromuscular dysfunction, musculoskeletal deformity, obesity, substance abuse, pregnancy, nutritional status, hydration status, and pain and discomfort.
* Describe the general preoperative, intraoperative, and post-operative course.
* Review specific, surgical procedures relevant to physical therapy (e.g., anesthesia, type of surgery, body position during surgery, airway, mechanical ventilation, duration, incisions, infusions, drainage systems, chest tubes, and recovery room.
* Provide the rationale for, describe, demonstrate, and have the patient practice and provide feedback on the following breathing control maneuvers: maximal inspiratory hold, supported coughing maneuvers, relaxation, bed mobility, and positioning, transfers, and mobilization
* For patients at risk of postoperative cardiopulmonary dysfunction and complications, review the use of the incentive spirometer and conventional airway clearance interventions(e.g., postural drainage and manual techniques, if indicated)
* Ask for any questions.

The **AIMS** of preoperative physiotherapy treatment are to:

* Gain the patients' confidence and reduce anxiety
* Educate the patient regarding postoperative routine
* Assess the patient risks of developing PPC
* Assist in the prevention of respiratory complications
* Assist in the prevention of deep vein thrombosis

Following a thorough assessment of the patient, including documentation of patient risk factors:

**EXPLAIN:**

* The role of the physiotherapist within the team
* The probable site of the incision
* Presence of drips/drains/oxygen therapy/ catheter/intercostals catheter
* Type of analgesia administered
* Effects of general anesthesia, surgery, and pain on the cardiorespiratory system
* The importance of optimal postoperative positioning, e.g. high-sitting, sitting out of bed, and the importance of regular deep inspirations and early mobilization for making an uncomplicated recovery.

**DEMONSTRATE/PRACTICE:**

* Deep breathing exercises to increase lung volumes
* Forced expiration technique (FET) and cough with support using a pillow or towel.
* Foot and ankle circulatory exercises
* Recommend the frequency and number of times for the deep breathing exercise, FET, supported cough, and foot and ankle exercises.
* Provide the patient with a written practice routine or information booklet, taking into consideration the language skills of the patient.
* For surgery such as a cardiothoracic, upper limb, and trunk exercises should be included in addition to education regarding underwater sealed drainage and discussion of rehabilitation on discharge.

**PERIOPERATIVE PERIOD :**

**THE OPERATIONS OF LUNG**

1. **PNEUMONECTOMY-**

Extrapericardial pneumonectomy/ standard pneumonectomy is carried out with division of the pulmonary vessels outside the pericardium and removal of carinal, paratracheal, and para oesophageal lymph nodes if they appear to be involved and involving the main bronchus. The whole lung is removed and the resulting cavity will fill with protein-rich fluid and fibrin over a period of weeks. Lateral shift of the mediastinum, an upward shift of the diaphragm, and reduction of the intercostals spacing on the operated side reduce the size of the cavity. Intrapericardial pneumonectomy/‘extended’ radical pneumonectomy, is a more radical procedure involving the removal of part of the pericardium. This is required when the tumor growth involves the pericardium.

All of the following indicates that the tumor is operable.

* Inability to separate the tumor from the aorta or superior vena cava.
* Inability to separate the tumor from the lower end of the trachea.
* Spread of growth along the pulmonary veins and to the left atrium so that the vein cannot be divided, even by ‘pinching up’ a portion of the atrial wall
* Spread of the growth along the pulmonary artery to such an extent that it cannot be divided even proximal to the obliterated ductus ateriosus on the left side of the medial to the superior vena cava on the right side.
* Inability to separate the tumor from vertebral bodies
* Involvement of oesophageal mucosa- if the growth involves only the muscle it may still be removable.

**Left extended pneumonectomy (intrapericardial)**

If the growth is extensive, with considerable mediastinal lymph node enlargement an early decision must be made on whether to open the pericardium. If so it is opened around the whole lung root, both anteriorly and posteriorly. It is preferable to retract the phrenic nerve anteriorly and not divide it to avoid paradoxical movement of the diaphragm and consequent difficulty in expectoration in the postoperative period. The situation of the growth, however, may make the division of the nerve necessary.

**Drainage after pneumonectomy**

A basal intercostal tube connected to an underwater seal should always be inserted after a pneumonectomy. This tube should be clamped but be released every hour for a minute only and the drainage noted. suction must never be applied as this would lead to too much mediastinal displacement and cause hypotension by impairing venous return to the heart. The tube is removed after 24 hours. If this routine is used any postoperative hemorrhage will be obvious. There is no risk of infection if the tube is removed after 24 hours and the need for postoperative aspiration is avoided. If the space is not drained the intrapleural pressure should be adjusted to a slightly negative level at the end of the operation by an intercostals catheter inserted through the third space anteriorly. This is then connected to an underwater seal and left in place until the patient has been placed on his back. It is then removed.

1. **LOBECTOMY**

**INDICATIONS**- Lobectomy is indicated in carcinoma of the bronchus if-

* The growth is relatively peripheral and confined to a lobe (or middle and right lower lobe) – in the case of an upper lobe growth, especially on the right; it is possible to obtain almost as good a clearance of lymphatic glands as by pneumonectomy.
* The patient is considered unfit for pneumonectomy because of age or impaired lung function.

The final decision on whether to carry out a lobectomy or pneumonectomy must remain until the operation because the growth may be more extensive than anticipated. Lobectomy is also carried out for bronchiectasis, lung abscess, benign tumors, and other miscellaneous conditions.

**Sleeve Lobectomy**  
A surgical procedure that removes a cancerous lobe of the lung along with part of the bronchus (air passage) that attaches to it. The remaining lobe(s) is then reconnected to the remaining segment of the bronchus. This procedure preserves part of a lung and is an alternative to removing the lung as a whole (pneumonectomy).

**WedgeResection**

A wedge resection is a surgical procedure during which the surgeon removes a small, wedge-shaped portion of the lung containing the cancerous cells along with healthy tissue that surrounds the area. The surgery is performed to remove a small tumor or to diagnose lung cancer. A wedge resection is performed instead of a lobectomy (removing a complete lung lobe) when there is a danger of decreased lung function if too much of the lung is removed. A wedge resection can be performed by minimally-invasive video-assisted thoracoscopic surgery (VATS) or a thoracotomy (open chest surgery).

**Segment Resection (Segmentectomy)**

A segment resection removes a larger portion of the lung lobe than a wedge resection, but does not remove the whole lobe, a segment of a lobe, with its segmental artery and bronchus**,**

**POSTOPERATIVE CARE**

After lobectomy or segmental resection, it is most important to obtain an early expansion of the remainder of the lung. It is also vital to prevent tracheobronchial infection and its sequelae by enthusiastic and efficient physiotherapy. The following measures are important.

1. Expectoration must be actively encouraged, verbally as well as by manual support of the chest on the side of the operation. If the sputum is thick and tenacious, 4 hourly inhalations of a mucolytic agent such as is very useful.
2. Analgesics will relieve thoracotomy pain and increase the effectiveness of expectoration. But excessive analgesia must be avoided as this will reduce the cough reflex and lead to sputum retention and lobar collapse.
3. Postural drainage should be carried out for one-half to one hour three times daily immediately after inhalations, or more often if expectoration of sputum is inadequate.
4. The antibiotic cover is generally given for 10 days, as so often patients undergoing lung resection have associated chronic bronchitis.
5. Ambulation is encouraged and the patient should be allowed out of the bed on the second or third day, even though chest drainage tubes are still in place.
6. Chest tube management will depend on postoperative progress. The apical and basal drainage tubes drain air and blood-stained fluid respectively. They are both connected to suction via underwater drainage bottles. They should remain in place for a varying number of days, depending on the amount of drainage and the radiographic appearances.

**OPERATIONS OF PLEURA**

1. **DECORTICATION**

AIM- the operation should result in full mobilization and expansion of normal lung, obliteration of the pleural space, and restoration of normal respiratory movements and function. if underlying lung tissue is diseased or destroyed, decortications can be combined with lobectomy or pneumonectomy.

**INDICATIONS**- Is indicated when thickened pleura so reduces movements of the lung, chest wall, and diaphragm that respiratory function is restricted to the extent of interfering with the patients' normal activity. Thickened pleura may result from the following.

* A previous tuberculous infection has left fluid enclosed by thickened pleura
* Failure of conservative measures to resolve completely acute empyema thoracis
* Organized and unresolved haemothorax.
* Idiopathic mediastinal and pleural fibrosis, asbestosis.
* **Previous lung resection**

Incision- a standard lateral thoracotomy is made through the bed of the sixth rib. There is usually considerable rib crowding and it is often necessary to resect one rib. Stripping of the pleura off the ribs should continue superiorly and posteriorly onto the mediastinum. Apical and basal intercostal drains are placed carefully through separate stab incisions. The thoracotomy is closed in layers and adequate suction is applied to the underwater drainage tubes as soon as the incision is closed.

**THORACIC SURGERY AND ITS CARDIOPULMONARY CONSEQUENCES**

* **Anesthesia and supplemental oxygen :**

Anesthesia results in depression of breathing. The thoracic respiratory excursion is significantly reduced. The tone and pattern of contraction of the respiratory muscles, particularly the diaphragm and the intercostal muscles, change, which contributes to many of the secondary cardiopulmonary effects observed after surgery.

The loss of end-expiratory diaphragmatic tone causes the diaphragm to ascend into the chest by two centimeters during anesthesia with or without paralysis. Reductions in functional capacity (FRC) are correlated with this change and with altered chest wall configuration and increased thoracic blood volume. One of the most pervasive and predictable clinical effects observed in the postoperative period is sitting collapse. Total lung capacity, FRC, and residual volume are significantly decreased. The FRC is significantly reduced in the supine position compared with the erect sitting position

The consequences of reduced FRC with anesthesia and surgery have significant implications for postoperative complications and the course of recovery. Airway closure with anesthesia and this likely contributes to intrapulmonary shunting. Compression atelectasis of the dependent lung fields occurs during surgery. In addition, compression atelectasis occurs when lung tissue and surrounding structures are being physically manipulated.

The airways may also be obstructed with foreign matter, such as blood and secretions, or from bronchospasm because of irritation of the airways. Because of the decrease in FRC, compliance is decreased and the work of breathing is increased. Hypoxemia secondary to transpulmonary shunting is usually maximal within 72 hours after surgery and often is not completely resolved for several days. Persistent reduction in FRC after surgery delays the restoration of the normal alveolar-arterial oxygen gradient.

Anesthesia and tissue dissection contribute to major changes in lung volume, mechanics, and gas exchange. The extent and duration of these changes increase with the magnitude of the operative procedure and the degree of anesthesia required.

The mismatch between DO2 and oxygen consumption is associated with a complicated clinical course and prolonged intensive care unit stay in the absence of conventional indicators such as low ejection fraction and longer cardiopulmonary bypass time. oxygen extraction increases to compensate for reduced DO2.

* **Reduction in vital capacity :**

VC is reduced by 50% to 75% within 24 hours after thoracic surgery. Normal adult VC is reported to range between 55 and 85ml/kg of normal body weight. The postoperative VC reduction occurs gradually over 12 to 18 hours following the surgical procedure.

Therefore, the patient’s ventilatory reserve usually will be significantly less 12 hours postoperatively than immediately following the surgical procedure and then gradually improves unless complications intervene. Most people with uncomplicated courses have a significantly reduced VC for 48- 72 hours, which then gradually returns to normal by 7 days. acute decreases in VC usually result in rapid and shallow ventilatory patterns.

* **The acute restrictive pattern :**

The predictable postoperative restriction in total lung capacity is believed secondary to the alteration of diaphragm and chest wall muscular activity. Here the thoracic cage is limiting the inflation capability of reasonably unaltered lungs, resulting in minimal diminishment of residual volume. It is also anticipated that hypoxemia resulting from this kind of restrictive pulmonary disease would be the result of low ventilation/ perfusion

**COMPLICATIONS**

**After the operation of the lung:**

1. **SPUTUM RETENTION** – Collapse/consolidation of a lobe or lung, together with diffuse bronchopneumonia, will occur if expectoration of sputum is inadequate. This will lead to respiratory insufficiency and general weakness, which in turn will cause increased difficulty in expectoration. Bronchoscopy must be carried out, and if this has to be repeated frequently a tracheostomy will be necessary. A recent innovation is a mini-tracheostomy in which a small suction tube is inserted through the cricothyroid membrane.
2. **ATRIAL FIBRILLATION**- Many patients over the age of 50 years will develop atrial fibrillation during the first 10 days after lung resection, especially if the pericardium has been opened. If the heart rate is fast, a shock-like condition may occur. The irregularity should be confirmed by ECG and requires urgent digitalization.
3. **BRONCHOSPASM-** this is best treated with ephedrine, salbutamol, or hydrocortisone.
4. **SURGICAL EMPHYSEMA** -Surgical emphysema will occur if the drainage tubes become kinked or blocked or if the air leak from the raw surface of the lung is greater than the suction pump can handle. The tube must either be made patent or replaced by a new tube, or the sucker must be removed to allow the free escape of the air through the bottle.
5. **HAEMORRHAGE**- If this is severe; the chest must be reopened to secure hemostasis.

**After the operation of pleura:**

1. **ATELECTASIS AND BRONCHIOPNEUMONIA** – Bronchopulmonary secretions may give rise to atelectasis and /or bronchopneumonia. If these do not respond to vigorous physiotherapy with postural drainage, orotracheal catheter aspiration or bronchoscopy may be required. In extreme cases, tracheostomy may be necessary.
2. **HAEMORRHAGE-** If blood loss through the intercostals drainage tubes exceeds 200ml/hour on more than one occasion within the first 12 hours postoperatively and/or there is clinical and radiological evidence of blood collecting in the hemithorax, a thoracotomy may be required. If large amounts of blood have been transfused a hematological check of the clotting factors is wise before a decision regarding reoperation is taken.
3. **PERSISTENT LARGE AIR LEAK**- If the sir leak is alveolar, suction on the drainage tubes at a flow rate greater than the rate of total air leakage from the lung surface probably will not exceed the patients' respiratory tidal flow and will produce early and complete expansion of the lung. This may require a negative pressure pump of several mmHg via tubs Barrett or Vernon Thompson pump.
4. **PERSISTENT AIR SPACE**- This will require obliteration by aspiration or tube drainage. Rib resection drainage may be required. In rare instances, thoracoplasty may be indicated.

**OTHER GENERAL COMPLICATIONS:**

**Atelectasis** (collapsed alveoli) occurs in typically 10-15% of the lung and lasts an average of 2 days postoperatively. The incidence of atelectasis and pneumonia after thoracic surgery has been reported to be 12-80%. The disparity is probably explainable by such variables as

(1) The Surgical Procedure,

(2) The Surgical Technique,

(3) Preoperative Status,

(4) Preoperative And Postoperative Care,

(5) Retrospective vs. prospective study

(6) Criteria For Diagnosis Of Atelectasis And Pneumonia.

**Atelectasis** creates a restrictive lung defect, reducing lung compliance, increasing airway resistance, and depleting surfactant. Persistent atelectasis may be associated with a chest infection but there is little evidence of causality. The left lower lobe is the commonest site, possibly because of compression from the heart. The causes are described below.

* Pain is the major culprit, dull at rest and sharp on movement. This leads to immobility and, after chest or abdominal surgery, guarding spasm of the trunk muscles and inhibition of breathing so that tidal breathing falls into the closing volume range.
* Prolonged recumbency affects the amount of ventilation causing intrathoracic pooling of blood which further displaces air from the lung.
* Drowsiness and immobility obliterate the regular oscillations in tidal volume that normally punctuate breathing and stimulate surfactant production.
* Absorption atelectasis is due to supplemental oxygen during anesthesia. This begins after about 40 min of 40% O2 and 5 min of 100% O2. It is augmented by the closed gas pockets created by reduced lung volume.
* Muscle tone is reduced.
* The diaphragmatic function may be impaired by abdominal distension.
* Sympathetic pleural effusion is a common, though usually minor, reaction to fluid over­load.

**Hypoxaemia**

There is a close correlation between atelectasis and shunt. Hypoxaemia is caused by the shunting of blood through airless lungs and the inhibition of hypoxic vasoconstriction by volatile anesthetic agents. Hypoxaemia may not be significant and many patients leave the hospital happily ignorant of its existence. For others, it can impair healing, promote infection and contribute to postoperative confusion. When present for a few hours it is related to the anesthetic. When present for several days it is related to the surgery and post­operative factors.

Patients at risk may suffer nocturnal hypoxemia for up to five nights after surgery. They have missed out on their rapid­eye-movement sleep due to disruption and medication, and as they catch up on this part of their sleep cycle, their oxygen requirements increase. Patients who have had major surgery, or those with respiratory or cardiovascular disease, should be monitored for nocturnal oxygen desaturation to prevent premature cessation of oxygen therapy. During surgery, the provision of oxygen has been shown to halve the incidence of wound infection.

**Fatigue** - is related to the degree of trauma during surgery and lack of nutrition after surgery. It is more severe and prolonged than expected by most patients, persisting for a month in two-thirds of people and directly affecting exercise capacity.

Frequent short walks should be negotiated rather than infrequent long ones. Some drugs contribute to the 'big little problem' of postoperative nausea. This is experi­enced by 20-30% of patients, some of whom find it a more wretched experi­ence than pain. It is commonest after lengthy surgery or in patients who are hypovolaemic, in pain, anxious, obese, or female. Nausea inhibits deep breathing, and vomiting can lead to complications such as fatigue, bleeding, dehiscence (separation of the incision or rupture of the wound), aspiration of gastric contents, delayed hospital discharge, and increased readmissions.

**Deep vein thrombosis** (DVT) is a blood clot that develops surreptitiously, usually during surgery. Causes are calf compression, immobility, fluid loss, manipulation of blood vessels, the surgical stress response which upsets clotting and depression because of the serotonin effect on platelet aggregation . DVT complicates one-fifth of major operations but is under diagnosed because it is clinically silent in 50% of patients. Signs may include tenderness, swelling and warmth of the calf, or sometimes pain on dorsiflexion (Homan's sign), any of which must be reported. Diagnosis can be confirmed by ultrasound or Doppler imaging. A DVT becomes serious if it breaks free and causes pulmonary embolism by lodging in the pulmonary vascular bed.

**LATE COMPLICATIONS:**

* **Emphysema after lobectomy or segmentectomy**

The diagnosis will be suspected by the onset of fever and radiological evidence of increased fluid, aspiration of which will reveal its purulent nature. The emphysema should be drained by rib resection. Emphysema may be associated with a bronchopleural fistula. This should be suspected if the patient is expectorating blood-stained purulent sputum and may be confirmed by the injection of the methylene blue into the emphysema and its subsequent appearance in the sputum the fistula will usually close spontaneously once the empyema is drained and the lung expands.

* **Post-pneumonectomy empyema**

This complication may or may not be associated with a bronchopleural fistula. If there is no fistula an attempt should be made to sterilize the empyema cavity by daily aspiration and instillation of an appropriate antibiotic . the initial aspiration should be through a thoracoscope to remove all infected fluid and fibrin. After 14 days the interval between aspirations can be increased, provided the fluid remains sterile. Frequently, however, it an impossible to sterilize the cavity. In some cases, a thoracotomy and evacuation of the pneumonectomy space will result in permanent sterility of the space.

After several months it may be wise to obliterate the pneumonectomy space by an extensive lateral thoracoplasty. If associated with a bronchopleural fistula, the empyema should be drained by rib resection followed about 6 months later, when the infection has subsided and if the patient is fit enough, by a lateral thoracoplasty (with preservation of the first rib) .complete healing occurs within a few weeks.

* **Post-pneumonectomy bronchopleural fistula:**

This complication is extremely serious and very often requires permanent tube or stoma drainage of the pneumonectomy space, and may even lead to death. The fistula almost always occurs on the right side, usually in those cases in which blood supply to the bronchial stump has been reduced by the removal of enlarged paratracheal lymph nodes. Most of the fistula occurs 7-21 days after the operation but it may occur after several months.

The sudden expectoration of blood-stained sputum, exacerbated by the patient lying towards the contralateral side and dramatically relieved by the patient lying on the pneumonectomy side, is diagnostic of this complication.

**POSTOPERATIVE PERIOD**

**ICU MONITORS AND EQUIPMENT**

It is common practice for patients who have had major surgery or trauma to spend some time in ICU. physical therapists who treat these patients should be familiar with the monitors, lines, pumps, drains, and other support equipment that is regularly used in the ICU. Some devices that are routinely seen after cardiac or thoracic surgery are described along with modifications that may be needed during physical therapy treatment.

**FEEDING TUBES**

Nasogastric tubes are commonly placed before surgery to prevent aspiration and because of decreased postoperative gastric motility. Oral gastric or nasogastric tubes are also used in emergency surgery to help evacuate stomach contents and during recovery from posttraumatic paralytic ileus. Feeding tubes are also used to provide supplemental enteral nutrition for patients unable to tolerate adequate oral intake. When the risk of aspiration is high or when long-term tube feeding is expected, small-bore tubes require endoscopic placement, whereas others are inserted percutaneously as gastrostomy tubes.

Physical therapists should note the type of feeding tube and where it terminates in the gastrointestinal tract before treatment. As a general rule to prevent aspiration, patients should not be positioned head-down for up to 30 minutes after a bolus gastric feeding. Continuous gastric feeding pumps should be stopped before chest physiotherapy is begun. Some tubes require a flush with water to prevent clogging when they are stopped for some time. feedings administered distally to the angle of traits in the jejunum can usually continue to run during physical therapy treatment, regardless of body position.

**CHEST TUBES**

Tube thoracotomy is often necessary after thoracic trauma since penetrating injuries, lung contusion, rib fractures, pulmonary lacerations, and vascular injuries lead to pneumothorax and hemothorax, intrapleural, and mediastinal drainage tubes are routinely placed after cardiothoracic surgery to aid in lung re-expansion. A subxiphoid incision, separate from the sternotomy incision, is used for mediastinal tubes. Hemothorax and pneumothorax are usually treated by inserting a drainage tube into the pleural cavity between the fourth and fifth intercostal space in the midaxillary line. Alternatively,

Pneumothorax may be ameliorated by placing a chest tube in the second intercostal space at the midclavicular line. Chest tube size is limited by the width of the intercostal space. using the largest tube which can be easily accommodated is recommended since discomfort is not reduced with the smallest gauged tubes; also drainage is enhanced and kinking is minimized

Patients with chest tubes can be mobilized. Transfers from bed to chair and short walks the limits of the tubing within the limits of the tubing are possible when wall suction is required. At the physician’s discretion, chest tubes can be temporarily left to water seal to allow ambulation for greater distances. Pain from the chest tube can lead to immobility and poor inspiratory effort.

Physical therapy aimed at achieving normal shoulder and thoracic motion is often necessary following thoracostomy tube insertion and should be coordinated with adequate pain relief. Chest physical therapy to treat an underlying condition, such as atelectasis or lung abscess, is indicated to improve lung expansion and may assist pleural drainage. Manual techniques of percussion and vibration are used as needed in patients with chest tubes.

**Leaks in plastic drainage apparatus**

Compartmental plastic units may crack with handling or develop invisible leaks. A large leak will interfere with the maintenance of suction and is usually discovered quickly. A small leak, however, falsely suggests a continuing air leak from the lung and may be present for a considerable period before the actual problem is discovered. To check for the leak, turn on the suction to -20cm H2O and observe the middle compartment. Air bubbling through the fluid indicates that air is entering the system, either from the pleural space or through the walls of the unit.

1. Leak in the apparatus: Clamp the drainage tube at the point where it enters the unit. If the bubbling does not stop, then the leak is suspected to be in the apparatus.
2. The leak is probably from the lungs: If the bubble ceases, then the unit is intact and the leak is probably from the lungs.

Thus it is important to clamp every part of the tube to check for a leak.

1. Leak in pleural space: Clamp the chest tube close to the skin, if the bubbling ceases then the source of air is the pleural space. To make sure that air is not being drawn into the chest around the tube, compress the skin around the tube with fingers, or vaseline gauze dressing is applied tightly around the entry site.

***Criteria of the chest tube removal*** depend on the indication for the insertion of the chest tube.

For pneumothorax, air leak must have ceased and the lung must be fully expanded on a chest radiograph before the tube can be removed. Also, it has to be confirmed that the lungs stay expanded without suction. Based on the available data, most physicians would obtain a chest radiograph 12-25hours after the last observed evidence of an air leak to ensure that the lungs are fully expanded before tube removal. If the placement of the tube was to drain any pleural fluid, once the drainage volume is less than 200ml in 24 hours, the fluid is serous, and the lung shows re-expansion on a chest film.

***Physiotherapy key points for handling patients with chest tubes***

* Advice should be given on postural correction and upper limb exercises. Occasionally inappropriate taping of the drains with sleek around the chest wall can limit the patient's range of movement and should be redressed.
* Care should be taken when handling patients so that the tubes are always visible, to avoid kinking, stretching, or disconnection.
* Bottles should be at the side of a patient's bed and not hidden underneath, to avoid crushing the container if the bed is in- advertently lowered too far.
* Observation of changes in air leaks and drainage should be made before, during, and after physiotherapy intervention.
* In the presence of an air leak, positive pressure techniques are usually avoided as they may perpetuate the problem.
* Patients requiring wall suction may compensate for a lack of mobility by walking on the spot. Alternatively, having sought approval from the medical staff, the suction tubing may be disconnected from the vent tube, enabling the patient to mobilize. It must be stressed to the patient that the drains are held below the level of the chest and that clamps should be available at all times.

**In Pneumonectomy**

Broncho pleural fistula is the most important complication post pneumonectomy. This occurs when the stump of the bronchus from which the lung tissue has been removed breaks down. The fluid here retains up to 8-10 days post-surgery thus the patient is advised to lie on the operated site to prevent the fluid from entering into the remaining lung tissue. This position also enhances the chest anteroposterior expansion at the cost of transverse excursion of the dependent lung. Compared to the supine position, this position will increase the compliance, reduce the resistance and decrease the work of breathing. After thoracotomy, lying on the affected side improves the arterial oxygen tension.

**In Lobectomy**

The operation has to be placed up. This position also enhances the chest anteroposterior expansion at the cost of transverse excursion of the dependent lung. Compared to the supine position, this position will increase the compliance, reduce the resistance and decrease the work of breathing. After thoracotomy, lying on the affected side improves the arterial oxygen tension

**CARDIAC MONITORS, INTRAVASCULAR LINES, AND DRAINS:**

Cardiac monitors rarely present a problem during physical therapy treatment. Electrode positioning may be altered to prevent artifacts and allow optimal hand placement during manual techniques.

Intravenous lines are no restrictions to physical therapy. To prevent dislodgement, the location of all IV lines should be noted and their patency checked before and after position changes. The presence of lines that monitor pulmonary artery and central venous pressure are not contraindications to turning or mobilizing patients. Waveforms should be checked after moving patients, but pressure readings displayed on the monitors normally vary with position changes, especially head-up and head down.

Arterial lines are used to monitor blood pressure and to obtain blood gas samples. These catheters do not prevent physical therapy treatment, but flexion around the joint where an arterial line is inserted may interfere with accurate readings. Therapists should be aware that arterial pressure normally fluctuates with changes in body position and when the relationship between the transducer, catheter placement, and right atrium is altered.

Intraabdominal drains are used to remove fluid or air from the surgical site. The drains are usually connected to collection bags and may require suction. Care is required to prevent tension and dislodging of intraabdominal drains. Indwelling urinary catheters should not be pulled or kinked when patients are repositioned. Drainage collection bags always are kept below the bladder to prevent reflux and infection.

**POSTOPERATIVE PHYSICAL THERAPY**

Generally, the main aims in the postoperative Phase are to promote the reinflation of areas of Atelectasis and to maintain adequate ventilation. Management includes assessment and treatment involving detailed explanations of breathing pattern disorders, and building an individual integrated recovery program based on:

* Breathing retraining
* Tension is released through talk and relaxation
* Stress perception and management
* Enjoyable graduated exercise prescriptions
* Rest/sleep guides.

**PRINCIPLES OF MANAGEMENT**

The goals of postoperative physical therapy management related to oxygen transport appear in the box at the right. These goals must be addressed between and during treatments. Thus the patient is in­structed in mobilization and body positioning coordi­nated with deep breathing and supported coughing.

**THE INITIAL PATIENT ASSESSMENT NOTES**

DATABASE: OBTAINED FROM MEDICAL NOTES

* Preoperative information: PFTs/ABGs(pulmonary function tests and arterial blood gases respectively)
* Surgical procedure and incision
* Concise relevant history of the present condition
* Relevant past medical history including previous surgery
* Social history
* Drug history, specific note of respiratory medicines; e.g. inhalers

SUBJECTIVE: INFORMATION THE PATIENT TELLS YOU

* Ask open-ended questions: how do you feel?
* Ask about pain control: can the person cough?

OBJECTIVE: INFORMATION BASED ON EXAMINATION OF THE PATIENT AND TESTS CARRIED OUT

* Cardiovascular status (CVS): blood pressure, heart rate, and rhythm
* Oxygen delivery system and FEV1
* Blood gases or O2 saturation
* Respiratory rate
* Chest x-ray
* Method of pain control
* Number and type of drains
* Auscultation
* Ability to cough
* Range of movement of shoulder on incision side

**GOALS OF POSTOPERATIVE PHYSICAL THERAPY**

*RELATED TO OXYGEN TRANSPORT*

* Maximize arousal
* Maximize alveolar volume
* Optimize alveolar ventilation
* Optimize perfusion
* Maximize lung volumes and capacities, especially
* functional residual capacity
* Minimize closing volume
* Minimize intrapulmonary shunting
* Optimize lung compliance
* Optimize mucociliary transport
* Optimize mucous clearance
* Optimize ventilation and perfusion matching and
* gas exchange
* Maximize expiratory flow rates
* Maximize chest tube drainage
* Optimize fluid balance systemically (renal function)
* Optimize lung water balance and distribution
* Promote optimal lymphatic draining
* Minimize third spacing and collection of fluid
* Minimize the risk of aspiration
* Minimize undue work of breathing
* Minimize undue work of the heart
* Maximize chest wall mobility and movement in three planes
* Optimize body and posture alignment when sitting, and standing. walking, and recumbent
* Optimize circulatory status and tissue perfusion
* Optimize peripheral blood flow and velocity
* Optimize muscle pump action
* Minimize effects of central fluid shifts with recumbency
* Maintain fluid-volume regulating mechanisms
* Minimize pain nonphal1nacologically and coordinate with the patient's pain medications if indicated
* Maximize cardiopulmonary endurance
* Optimize relaxation
* Provide instruction to the patient on "between-treat­ment" treatment maneuvers between treatment sessions, and these in­terventions should be performed hourly during waking hours

Pain medications are coordinated as needed with treatments to maximize treatment efficacy.

In addition to goals related to oxygen transport, other important postoperative goals include the following:

I. Maximize joint range of motion

2. Maximize muscle length and ligament integrity with a range of motion exercises

3. Maximize patient's ability to perform activities of daily living

4. Maintain or increase general muscle strength and endurance

5. Maintain normal cognitive function to avoid disorientation and hospital-related psychoses.

These goals are achieved with the prescription of general mobility exercises, including hip and knee flexion and extension exercises, and foot and ankle exercises. These exercises are performed hourly regardless of whether the patient is sitting in a chair or resting in bed. Finally, there are important preventative goals (e.g., minimizing the effects of restricted mobility and recumbency on all organ systems). Of particular concern in the surgical patient are at the risk of developing thrombo-emboli and pulmonary emboli and the risk of pressure points and skin breakdown. Thus mobilization and regular activation of the muscle pumps to minimize circulatory stasis and frequent body position changes are essential to reduce risks, which can have serious consequences for the patient's recovery.

Compression stockings are often put on the patient after surgery. These are not removed other than for cleaning and redistributing pressure until the patient is consistently up and about. These stockings facilitate venous return and increase blood flow and velocity, thereby minimizing the risk of thrombus formation. Should thrombus formation be suspected, an intermit­tent compression device may need to be attached to the legs to simulate muscle pump action.

Not all patients who have surgery are intubated. Those that are, except for patients undergoing thoracic or cardiovascular surgery, are usually extubated before leaving the operating room or recovery area. Provided no complications develop, most other patients do not require an airway. Patients undergoing major thoracic surgery or cardiovascular surgery remain intubated and mechanically ventilated from several to 24 hours after surgery to minimize the work of breathing and hence the work of the heart to meet the metabolical demands of respiration. These patients are informed that artificial airways and mechanical ventilation enable them to breathe more efficiently initially. A patient is also informed that he or she will not be able to speak while the airway is in place and may have a sore throat after its removal. Patients are usually aroused and repositioned be­fore leaving the operating room, although this is seldom remembered by patients. Not recalling the immediate postoperative course is common. Patients are likely to be receiving some form of pharmacological analgesia (e.g., morphine). If blood was required intraoperatively, whole blood, packed cells, or plasma may still be infused in the immediate postoperative period or longer. Saline or other solutions are also in­fused for regulation of fluid balance until the patient can drink and eat normally.

Once vital signs have stabilized, wounds are stable and not draining, and the patient is reasonably alert, the patient is transferred to the ward. The patient is retained in the recovery area should further monitoring be required. If complications develop and oxygen transport and gas exchange are threatened, the patient may be transferred to the intensive care unit. The physical therapist may be consulted to assess and treat the patient as soon as he or she leaves the operating room or while in the recovery room. Most frequently the physical therapist sees the patient once he or she has been transferred to the ward and has been settled. The first 24 hours are critical.

The risk of cardiopulmonary complications is greatest during the perioperative period and diminishes as the patient becomes increasingly upright and mobile. Atelectasis and aspiration after extubation are significant risks for the patient who has been intubated. The goal immediately after extubation is to promote optimal alveolar ventilation, maximize lung volumes and capacities (especially FRC), minimize closing volumes, and maximize expiratory flow rates and hence cough effectiveness. Areas most susceptible to atelectasis are those that may have been physically compressed during surgery (e.g., the left lower lobe of the cardiovascular surgical patient and areas adjacent to a lobectomy or segmentectomy).

**Pain** - Perception of pain varies with some factors that physiotherapists cannot modify such as the operative technique and previous experience. However, physiotherapists can modify other factors

* Anxiety or fear
* Physical discomfort
* Physical tension
* Lack of autonomy or privacy
* Depression
* Sleep fragmentation

Physical tension can be eased by posture change or relaxation. Anxiety can be reduced by keeping patients informed. Autonomy can be enhanced by including them in decisions. During the activity, patients need reassurance in words and actions that they will be heard and responded to. 'Tell me if it hurts and I'll stop’ is music to their ears. The essence of physiotherapy is skillful handling, and there are few rewards greater than relief on the face of a patient whose pain we have eased. Handling and positioning are as important in relieving acute pain as drugs. Manual handling for patients in pain incorporates the principles of offering advice and support but allowing patients to move them­selves as much as possible. For rolling into side lying, patients can be asked to bend their knees, shift away from the direction in which they are to roll, hold onto the bed rail, push with their knees and roll in one piece. If a bed rail is not available, physiotherapists can ensure that the bed is the right height, then press their own fist into the bed, to protect their back, and the patient hold s on to their straight supported arm.

**Heated humidification**:

Pulmonary secretions can become tenacious following surgery. This may be due to anaesthesia, infection, or dehydration –especially in the oesophageal patients who are 'nil by mouth'. Improving humidification to the airways by heating the oxygen/air delivery can help in mucous clearance.

**Incentive Spirometry***:*

Incentive spirometry is a feedback system to encourage patients to take a deep breath and produce a sustained maximal inspiration to open atelectatic areas of the lung. It is cheap to provide, non-invasive and when taught well needs minimal supervision. It is deduced that deterioration in incentive spirometer performance could be used as a warning of pulmonary deterioration.

**Breathing exercises**

Thoracic expansion exercises are deep breathing Exercises emphasizing inspiration. Inspiration Is active and may be combined with a 3-second Hold for the passive relaxed expiration. The Postoperative maneuver of a 3-second hold at Full inspiration has been said to decrease the collapse Of lung tissue. This 'hold 'may Also be of value in some patients with medical Chest conditions, but it is probably inappropriate In the very breathless patient. In the normal lung the resistance to airflow Via the collateral ventilatory system is high, but With increasing lung volume and in the presence Of lung pathology the resistance decreases, allowing air to flow via the collateral channels-the pores of Kohn, channels of Lambert, and Channels of Martin.

The air behind secretions may assist in Mobilizing them. The effectiveness of thoracic expansion exercises in re-expanding lung tissue and in mobilizing and clearing excess bronchial secretions can Also be explained by the phenomenon of inter-dependence. This is the effect of The expanding forces exerted between adjacent alveoli. At high lung volumes, the expanding forces between alveoli are greater than at tidal volumes and assist in the re-expansion of lung tissue. Three or four expansion exercises are usually Appropriate before pausing for a few seconds For a period of breathing control. Any more Deep breaths could produce the effects of hyperventilation or could tire the patient. Thoracic expansion exercises can be encouraged With proprioceptive stimulation by placing a hand, either the patient's or the physiotherapist’s, over the part of the chest wall where Movement of the chest is to be encouraged.

The forced expiration technique is a combination Of one or two forced expirations (huffs) and Periods of breathing control. Huffing to low Lung volumes will move the more peripherally Situated secretions and when secretions have reached the larger more proximal upper airways. A huff or cough from a high lung volume can be Used to clear them. With any forced expiratory maneuver there Is dynamic compression and collapse of the Airways downstream (towards the mouth) of the equal pressure point. This is an important part of the clearance mechanism of either a huff or a cough. As lung volume decreases during a forced Expiratory maneuver the equal pressure points Move more peripherally, and below functional Residual capacity, they move towards the alveoli. At lung volumes above functional residual capacity, the equal pressure points are located In lobar or segmental bronchi.

A series of coughs without intervening inspirations to clear bronchial secretions, but clinically a single Continuous huff down to the same lung volume Is as effective and less exhausting. Comparing cough and the FET concluded that both were equally effective in clearing lung Secretions, but that the FET required less effort from the patients. When mobilizing and clearing peripheral Secretions it is an unnecessary expenditure of energy to start the huff from a high lung volume. A huff from mid-lung volume is more efficient and probably more effective. To huff from the mid-lung volume, a medium-sized breath should be taken in, and with the mouth and glottis open, The air is squeezed out using the chest wall and Abdominal muscles. It should belong enough To loosen secretions from the more peripherally Situated airways and should not just be a clearing Noise in the back of the throat. However, if The huff is continued for too long it may lead to Unnecessary paroxysmal coughing. Too short A huff may be ineffective, But when the secretions have reached the upper airways, a shorter huff or a cough from a high lung volume is used to clear them. The huff is a forced but not violent maneuver. To be maximally effective the length of the huff And force of contraction of the expiratory muscles Should be altered to maximize airflow from the Periphery and to minimize airway collapse.

An essential part of the forced expiration Technique is the pause for breathing control after one or two huffs which prevent any increase in airflow obstruction. The length of the pause Will vary from patient to patient In a patient With bronchospasm or unstable airways, or in One who is debilitated and fatigues easily, longer Pauses (perhaps10-20 seconds)may be appropriate. In patients with no bronchospasm, the Periods of breathing control may be considerably Shorter (perhaps two or three breaths or 5-10 seconds).

**Supported Cough**

A cough is created by a forced expiration against a closed glottis. This causes a rise in intrathoracic pressure. As the glottis opens there is rapid, outward airflow and shearing of secretions from the airway walls. Improved coughing and FET can be achieved if the wound is supported. This can be done by the physiotherapist during treatment sessions or by the patient. The arm on the unoperated side is placed across the front of the thorax and over the incision and drain sites. The firm overpressure is applied during coughing/FET. A towel, folded lengthways, passed around the back of the patient and pulled across the front of the thorax canal so be useful to support coughing.

Surgery constitutes a significant insult to the body. After the trauma of surgery, anesthesia, sedation, fluid loss, incisions, and the significant energy requirements for healing and repair, patients can be expected to be lethargic and difficult to arouse. The relaxed state induced by anesthesia, sedation, and narcotics increases the risk of aspiration. This risk is exacerbated further in some patients by nausea and vomiting associated with anesthesia and narcotics.

Moving and positioning the patient upright whenever possible and interacting with the patient stimulates the reticular activating system making the patient more responsive and aroused. The increased metabolic demands that this requires, along with increased catecholamine release, help overcome the residual effects of anesthesia, sedation, and muscle relaxants and their threat to oxygen transport, provided the demands are not beyond the capacity of the oxygen transport system to deliver oxygen. Alternatively, some patients are restless and agi­tated after the effects of the anesthesia have worn off. Hypoxemia can lead to restlessness and agitation. Thus these patients must not be inap­propriately sedated. This compounds their need for treatment while making them less able to cooperate with a treatment simultaneously.

At the outset of any treatment, the patient must be aroused as much as possible to cooperate fully and derive the maximal benefit from treatment. The physical therapist interacts continuously with the patient to arouse the patient fully, maintain arousal, stimulate normal cognitive function and orientation, and elicit feedback from the patient to assess the response to treatment. Narcotics depress respiratory status and arousal, and these effects are accentuated in patients whose metabolic states have been disrupted with illness and in older persons. Thus the physical therapist must be vigilant in detecting untoward residual effects of narcotics in the surgical patient.

**Mobilization i**n the upright position coordinated with breathing control and supported coughing maneuvers is encouraged immediately after the patient is first aroused after surgery, unless contraindicated, to help reverse and mitigate reduced arousal, atelectasis, FRC, and impaired mucociliary transport associated with surgery. Mobilization augments cardiopul­monary function particularly when the patient is upright. These beneficial effects are enhanced by improved three-dimensional chest wall motion, improved gut motility, and reduced intraabdominal pressure.

Extremity movement during ambulation increases alveolar ventilation, enhances ventilation and perfusion matching by increasing zone 2 of the lungs, and optimizes diffusing capacity. The upright position is essential such that the spine is erect, the upper body musculature relaxed, and the chest wall symmetrical. Slouching and leaning particularly to the affected side reduces alveolar ventilation and contributes to uneven distribution of ventilation and areas of atelectasis. In addition, if this abnormal posture is maintained, mucociliary transport of the area is impaired and mucus collects and stagnates, increasing the risk of bacterial colonization and infection. Symmetrical posture is monitored at all times (i.e., during ambulation, sitting at bedside, bed mobility exercises, sitting up in bed, and lying in bed). Slouching and favoring the affected side will lead to cardiopulmonary complications and possibly musculoskeletal complications in the short and long term.

Mobilization and active exercise in upright postures whenever possible are prescribed based on the need to enhance multiple steps in the oxygen trans­port pathway. The priority is to perform as much activity as possible out of bed and upright (i.e., ambulation, transferring, sitting upright in a chair, and chair exer­cises with or without hand weights or exercise bands). When in bed, similar devices can be used, including a monkey bar to facilitate moving in bed for patients other than cardiovascular thoracic patients (e.g., the orthopedic patient with extremity fractures and traction). In addition, the use of the monkey bars to perform repetitive bouts of exercise to maintain upper-extremity strength and some general endurance capacity, to relieve pressure and stiffness.

**POSTOPERATIVE REGIME:**

**THORACOTOMY**

The following plan is suitable for wedge, segmental, and sleeve resections, lobectomy, or simple thoracotomy.

**DAY OF OPERATION**

Oxygen therapy is usually administered for the first few hours after the patients return to the ward. Although the patient will still be drowsy from the anesthetic full range of active /assisted shoulder movements should be carried out. As the incision cuts through the latissmus dorsi these exercises must begin immediately to prevent muscle shortening and adhesions.

The patient should be able to cooperate with the breathing exercises and cough with support. The physiotherapist should support the operation side firmly, but gently, taking care not to press directly on the incision or drainage tube sites. The patient should be reminded that the exercises should be continued each time he wakes from the sedation.

**DAY 1**

The treatment plan should be followed, first ensuring that the patient is in a comfortable position when side-lying. To achieve this position, the patient should sit forward with the physiotherapist on the operation side, who should re-arrange the pillows, leaving only one on the bed. The patient turns to the side sitting toward the unaffected side; the patient’s body weight must be supported at the shoulder as he lowers on his elbow and then into side-lying. Positioning of the pillows for maximum comfort of the patient and support of the drains. If the patient is rolled back on the pillow (quarter-turn up from supine) it ‘opens up the anterior chest wall and facilitates coastal movement while still draining the affected lung. If the patient rolls forward on the pillow (quarter-turn up from prone) it allows unrestricted posterior chest movement.

Three treatment sessions throughout the day will probably be necessary, all with adequate analgesic cover. The patient will probably sit out of the bed that morning for as long as he wishes. He should be encouraged to practice breathing, coughing, limb and shoulder girdle exercises, and correct his posture, regularly during the day.

When the patient is sitting in bed, the pillows should be arranged to support the patient in a good posture without undue pressure on the site of the incision and drainage tubes. Five pillows should be used: one placed crossways at the bottom; the next two cross-ways at the shoulder and head level. The two vertical pillows should be placed to support the lumbar area, yet be contoured so that the pressure is relieved over the incision. The body weight is then supported bilaterally at shoulder level.

**DAY 2**

Chest treatment should be given two-three times, depending on the chest radiographs and auscultation. With the patient sitting on a firm chair trunk exercises can be added to the regime. As soon as the drains are off suction, mobilization is increased quickly and stair climbing is added as soon as possible.

**DAY 3 TO DISCHARGE**

The patient needs to be assessed daily during the following week, treating his chest as necessary. Postural exercises and general activities should be progressed. The patient will probably go home8-10 days postoperatively; follow-up physiotherapy should not be necessary unless the shoulder has been a particular problem.

**PNEUMONECTOMY**:

Preoperatively patient is advised not to lie on his good side for approximately 10 days after the operation. This will prevent the fluid in the pneumonectomy space from covering the bronchial stump thereby decreasing the risk of any breakdown of the suture line with possible development of the broncho-pulmonary fistula.

Because coughing creates a back pressure which can traumatize the bronchial stump, huffing must be taught and encouraged, to move secretions before a final gentle clearing cough.

**Postoperative treatment plan**

1. Ensure the patient has adequate analgesia
2. Deep breathing exercises (unilateral costal on the good side and diaphragmatic with inspiratory holds and sniffs in sitting or half lying
3. a) Unilateral shakings on the good side during expiration

b) Huffing with good support on the incision

1. Full range active/assisted shoulder exercises.
2. Active leg, foot, and ankle exercise.
3. a) Bilateral costal and diaphragmatic breathing exercises.

b) Trunk and shoulder girdle exercises and postural correction

1. Early mobilization with controlled breathing patterns is designed to improve exercise tolerance.

**DECORTICATION/ PLEURECTOMY:**

The immediate postoperative period is particularly painful and adequate analgesia must be given to achieve a satisfactory treatment. The intercostal drainage tubes must never be clamped as retention of air and/ or fluid in the chest will prevent the lung from adhering to the chest wall.

**Postoperative Regime**

This will follow the described above program and will start on the day of operation. Care of drainage tubes together with the costal and diaphragmatic breathing exercises and coughing will be carried out with the patient in the side-lying position and the affected lung uppermost; the foot of the bed will be elevated. Special efforts must be made to regain maximum rib and diaphragmatic movement. There may have been very limited chest movement before decortications of empyema and every effort should be made to increase the local movement postoperatively. The patient will sit out of the bed on the first day and commence walking as soon as possible. All exercises are increased and postural drainage continued until intercostal tubes and/ or all excess secretions are removed. Walking, stair climbing and general exercises should continue until discharge, then all movements should be unrestricted and the posture free and upright template for progressing mobilization in surgical patients

|  |  |  |  |
| --- | --- | --- | --- |
| **Level** | **activity** | **Bathroom** | **Bathing** |
| **1** | **Confined to bed assessment**  **Body positioning** | **Portable toilet when possible** | **Personal care by nurse** |
| **2** | **Sit up in the chair for 20 minutes, 3 times a day** | **Use portable toilet** | **May wash in bed(not legs, back, or feet)** |
| **3** | **Sit up in your chair as much as possible** |  | **Bathe at bedside** |
| **4** |  | **Walk to bathroom** | **Bathe in a sink (sitting)**  **Bathe at sink** |
| **5** | **Walk around the room as able** |  |  |
| **6** | **Short walks in the hall 2 to 3 times per day** |  |  |
| **7** | **Walk-in hall as able** |  | **Take shower (sitting) or tub bath** |
| **8** | **Walk one flight of stairs with assistance** |  |  |
| **9** | **discharge** |  |  |

**Arm Exercises after surgery**

All exercises should be done on the operation side, up to the point where you start to feel either a stretch or pain (or both). You should not push through pain or over-stretch at this point.

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