



BRIGHAM AND WOMEN'S HOSPITAL

Department of Rehabilitation Services Physical Therapy

Standard of Care: Pulmonary Disease

Inpatient Physical Therapy Management of the Surgical and Non-Surgical Patient with Pulmonary Disease

ICD 9 Codes:

162.0 Malignant Neoplasm of the Trachea, Bronchus and Lung
163.0 Malignant Neoplasm of the Pleura
165.0 Malignant Neoplasm of Other and Ill-defined Sites Within the Respiratory System and Intrathoracic Organs
493.0 Extrinsic Asthma
493.1 Intrinsic Asthma
493.2 Chronic Obstructive Asthma
493.8 Other Forms of Asthma
493.9 Asthma Unspecified
491.0 Simple Chronic Bronchitis
491.2 Obstructive Chronic Bronchitis
491.9 Unspecified Chronic Bronchitis
492.8 Other Emphysema
496.0 Chronic Airway Obstruction
506.4 Chronic Respiratory Conditions due to Fumes and Vapors
494.1 Bronchiectasis with Acute Exacerbation
512.0 Spontaneous Tension Pneumothorax
512.1 Postoperative Pneumothorax
518.0 Pulmonary Collapse
518.4 Acute Edema of the Lung
518.5 Pulmonary Insufficiency Following Trauma and Surgery
518.82 Other Pulmonary Insufficiency not Elsewhere Classified

Case Type / Diagnosis:

This standard of care applies to patients with pulmonary disease including, but not limited to obstructive lung disease and restrictive lung disease. The obstructive lung diseases included in this standard of care are chronic obstructive pulmonary disease (COPD), asthma, and bronchiectasis while the restrictive diseases included are idiopathic pulmonary fibrosis (IPF), asbestosis, bronchopulmonary dysplasia (BPD), atelectasis, bronchiolitis obliterans, pneumonia, adult respiratory distress syndrome (ARDS), bronchogenic carcinoma, pleural effusion, sarcoidosis, pulmonary edema, pulmonary emboli, diaphragmatic paralysis or paresis, kyphoscoliosis, spinal cord injuries (SCI), demyelinating disorders, rib fractures, flail chest. This includes a wide spectrum of patients including patients admitted for medical/surgical management due to their primary pulmonary diagnosis.

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This standard of care does not apply to patients with cystic fibrosis (CF) or lung transplant for standard of PT practice. For information regarding the physical therapy (PT) management of patients with CF please refer to Standard of Care: Cystic Fibrosis. For information regarding the management of patients after lung transplant please refer to Standard of Care: Inpatient Management of the Patient Status Post Lung Transplant.

Indications for Treatment:

Understanding normal and abnormal pulmonary physiology is important for PTs in the acute care setting in order to distinguish whether a patient has restrictive or obstructive disease. The PT treatment of these two types of pulmonary disease varies and understanding this physiology helps to direct the therapy intervention and treatment plan.

Normal Pulmonary Physiology

In healthy, normal pulmonary physiology, respiration occurs as a result of diffusion, perfusion, and ventilation. Respiration is the process of gas exchange in the lungs facilitated by diffusion. Diffusion is the movement of gases from areas of high concentration to areas of low concentration. Oxygen (O₂) naturally diffuses into pulmonary capillaries to oxygenate the body while carbon dioxide (CO₂) diffuses into alveoli for exhalation. Perfusion is the amount of blood flow to the lungs which allows this diffusion to occur. Ventilation is the mechanical movement of air into and out of the lungs.

The normal ventilation/perfusion (V/Q) ratio is 0.8 as alveolar ventilation is ~4 L/min and pulmonary blood flow is ~5 L/min. Ventilation is optimized in areas of least resistance such as areas where alveoli are more expanded. Perfusion is greatest in gravity dependent areas; therefore in sitting the upper lobes initially receive more ventilation while perfusion is greatest at the base of the lungs. In supine perfusion is greatest in the posterior lung fields while ventilation is greatest in anterior lung fields.

Impaired Pulmonary Physiology

In some cases of impaired pulmonary physiology a venous admixture is created which is a mixing of unoxygenated blood with oxygenated blood. This has two causes: an anatomic shunt, and a low V/Q ratio. An anatomic shunt occurs when blood bypasses alveoli; in the lungs this occurs when bronchial venous blood (deoxygenated) drains into pulmonary veins (oxygenated) in conditions involving consolidation, such as pneumonia or pulmonary edema. A low V/Q ratio occurs when there is insufficient alveolar ventilation to fully oxygenate all of the blood passing through pulmonary capillaries. A physiological shunt describes blood that is not oxygenated due to inadequate ventilation. Physiological dead space is wasted oxygen which is not absorbed by blood due to impaired diffusion.

Obstructive lung disease

Obstructive lung disease is a disease of the airways that produces obstruction to expiratory airflow. This obstruction may be caused by different mechanisms that decrease the size of the bronchial lumen and/or increase the resistance to expiratory airflow. Common signs and symptoms of obstructive lung disease are dyspnea on exertion (DOE), cough, secretion production, tachypnea, hypoxemia, decreased breath sounds.

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- A. Chronic obstructive pulmonary disease (COPD):
- a. Definition: COPD is a generic term referring to lung diseases that cause air trapping resulting in hyperinflation of the lungs. It is most commonly a combination of emphysema and chronic bronchitis. Emphysema is the destruction of the alveolar walls and enlargement of the air spaces distal to terminal bronchioles. It is associated with bullae which are large air collections within a thin outer wall which can cause spontaneous pneumothorax. Chronic bronchitis is the hypersecretion of mucus that begins in large airways and eventually leads to the thickening of airway walls and airway obstruction. The diagnosis criteria for chronic bronchitis are the presence of a productive cough for three months in two successive years with other causes of chronic mucus production ruled out.
 - b. Cause: An abnormal inflammatory response in the lungs resulting in increased lung compliance, larger lung volumes, and air trapping as a result of premature closure of the airways. Smoking is a major cause of COPD.
 - c. Signs and symptoms: Barrel chest, dyspnea on exertion (DOE), cough, hypoxemia, hypercapnia, prolonged exhalation, decreased breath sounds ^{1,2}
 - d. Medical Management: Goals are to relieve symptoms and prevent progression via smoking cessation and pharmacotherapy to reduce airflow limitations with bronchodilators and anti-inflammatory agents.
- B. Asthma:
- a. Definition: Asthma is a chronic inflammatory disorder of the airways with episodes of acute inflammation. These acute episodes can contribute to airway remodeling or thickening of walls in large and small airways.
 - b. Causes: Asthma is thought to be caused by environmental and genetic factors.
 - c. Signs and symptoms: Classic signs and symptoms are wheezing, chest tightness, dyspnea which are often precipitated by exercise, cold air, exposure to allergens or viral respiratory infections.
 - d. Medical Management: Focus is on emphasizing the importance of long term control as opposed to simply treating episodes of exacerbation. This includes elimination of factors that worsen symptoms such as allergens. Pharmacologic therapy is used to reverse and prevent bronchoconstriction. Short term “rescue” medications act to reverse acute bronchospasm. Examples of these are Albuterol and Atrovent. Long term “controllers” act as anti-inflammatory, long acting bronchodilators such as inhaled corticosteroids that prevent bronchoconstriction. Pulmonary function tests can be used to assess severity and rate the effectiveness of therapy.
- C. Cystic Fibrosis (CF): see Standard of Care: Cystic Fibrosis

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D. Bronchiectasis:

- a. Definition: Bronchiectasis is irreversible dilation of one or more bronchi with chronic inflammation and infection.
- b. Causes: Bronchiectasis is caused by bronchial wall injury as a result of fibrotic changes caused by a restrictive lung disease such as sarcoidosis and interstitial fibrosis in which the airway is pulled outward resulting in fixed dilation of the airways. It can also be caused by bronchial lumen obstruction from slow growing tumors or fibrotic strictures due to prior infection such as tuberculosis.
- c. Signs and symptoms: The hallmark sign of bronchiectasis is a cough with chronic sputum production with 3 layers: white frothy top layer, mucoid inner layer, and a purulent bottom layer. Other signs and symptoms include dyspnea and fatigue.
- d. Medical Management: Focuses on reducing the number of exacerbations and improving quality of life. This includes antibiotics for acute infections, nebulized medication, bronchodilators, and secretion clearance.

Restrictive lung disease (RLD)

Restrictive lung disease is a group of diseases which cause abnormal reduction in pulmonary ventilation due to decreased compliance of the lung and chest wall. This decreases lung volumes and increases the work of breathing.

Pulmonary Causes

A. Idiopathic pulmonary fibrosis (IPF):

- a. Definition: IPF is an immunologically mediated inflammatory process involving the alveolar wall which progresses to fibrosis and decreased compliance of the lung architecture².
- b. Causes: IPF usually begins with an initial acute injury or infection and causes a progressive decline in lung function.
- c. Signs and Symptoms: Decreased total lung capacity (TLC), vital capacity (VC), functional residual capacity (FRC), residual volume (RV), decreased arterial partial pressure of O₂ (PaO₂), bibasilar end-inspiratory dry crackles, decreased breath sounds, cyanosis, digital clubbing, DOE progressing to dyspnea at rest, repetitive non-productive cough, weight loss, fatigue, increased work of breathing
- d. Medical Management: Corticosteroids are the gold standard treatment while other pharmacologic treatment includes aggressive treatment of infection. Smoking cessation is also important. Lung transplantation is also used; for more information please see Standard of Care: Inpatient Management of the Patient Status Post Lung Transplant.

B. Asbestosis

- a. Definition: Asbestosis is a diffuse interstitial pulmonary fibrotic disease.
- b. Cause: Asbestosis is caused by exposure to asbestos with unclear pathophysiology. It is thought that asbestos fibers cause alveolitis in respiratory bronchioles which progresses to peribronchiolar fibrosis.
- c. Signs and Symptoms: Decreased PFTs, clubbing of nail beds, DOE progressing to dyspnea at rest, chronic cough which may or may not be productive
- d. Medical Management: The focus of treatment is on symptomatic support such as smoking cessation.

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- C. Bronchopulmonary Dysplasia (BPD)
 - a. Definition: BPD is a disease characterized by acute and chronic lung changes resulting in inflammation of lung parenchyma.
 - b. Cause: BPD occurs in survivors of respiratory distress syndrome (RDS) who have been mechanically ventilated and received high concentrations of O₂ for long periods of time.
 - c. Signs and Symptoms: wheezing, impaired airway clearance, dyspnea
 - d. Medical Management: Bronchodilators
- D. Atelectasis
 - a. Definition: The incomplete expansion of alveoli or loss of volume of all or part of a lung.
 - b. Causes: Can be caused by the collapse of alveoli caused by a pneumothorax or compression of the alveoli as a result of interstitial or pulmonary edema. It can also be caused by a post-operative incision causing the inability or unwillingness to cough effectively or take deep breaths leading to secretion retention. The obstruction of airways as a result of tumors, enlarged lymph nodes can also cause atelectasis.
 - c. Signs and Symptoms: dyspnea, increased work of breathing
 - d. Medical Management: Focuses on deep breathing, incentive spirometry, coughing, and airway clearance techniques. If these techniques are not sufficient bronchoscopy can be performed to suction secretions which may be causing atelectasis.
- E. Bronchiolitis Obliterans: also called bronchiolitis obliterans with organizing pneumonia (BOOP)
 - a. Definition: Necrosis of the respiratory epithelium allows fluid and debris to enter bronchioles and alveoli causing obstruction and eventually atelectasis. This is followed by an inflammatory response which causes fibrotic changes in the bronchial tree and alveoli.
 - b. Cause: There are a few causes including toxic fume inhalation, viral or bacterial agents, and it can be associated with organ transplantation and other diseases such as IPF.
 - c. Signs and Symptoms: Decreased PFTs, hypoxemia, expiratory wheezing, dyspnea, increased respiratory rate, non-productive cough.
 - d. Medical Management: Focus includes supplemental O₂, fluid balance, and corticosteroids.

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F. Pneumonia:

- a. Definition: An inflammatory process of lung parenchyma classified as either community acquired pneumonia (CAP) or hospital acquired pneumonia (HAP) (nosocomial).
- b. Cause: Begins with an infection in the lower respiratory tract caused by various microbes. It can be caused by bacteria, viruses, or aspiration. The most common bacteria causing CAP is streptococcus pneumoniae (pneumococcus). Patients most at risk for HAP have one or more of the following factors: NG tube, intubation, dysphagia, tracheostomy, mechanical ventilation, lung injury, chronic cardiopulmonary disease, advanced age, or high O₂ concentrations. Aspiration pneumonia occurs when foreign material is inhaled into the lungs (most commonly food, liquid, vomit).
- c. Signs and Symptoms: Bacterial presents with an abrupt onset with lobar consolidation, high fevers, productive cough, pleuritic pain, leukocytosis. Viral presents with an insidious onset with patchy diffuse bronchopulmonary infiltrates, moderate fever, nonproductive cough, myalgia, normal WBC count. Aspiration presents with dyspnea, wheezing, productive cough, and fatigue.
- d. Medical Management: Antibiotics, pathogen specific if possible or multiple antibiotics if not. Oxygen and mechanical ventilation/non-invasive ventilation may be necessary.

G. Adult Respiratory Distress Syndrome (ARDS)

- a. Definition: Severe hypoxemia and increased permeability of the alveolar-capillary membrane which allows excess fluid and plasma protein to leak into interstitial fluid and alveoli causing decreased gas exchange.
- b. Cause: Caused by acute lung injury via trauma, aspiration, inhaled toxins, shock, sepsis, primary pneumonias and metabolic causes. May resolve completely, however, in some patients significant lung damage occurs. The longer the patient is on mechanical ventilation and high O₂ concentration, the poorer the long term prognosis.
- c. Signs and Symptoms: Tachycardia, dyspnea, increased and shallow respiratory rate, cyanosis, increased anxiety
- d. Medical Management: Focuses on treating the underlying cause and supporting gas exchange via mechanical ventilation.

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H. Bronchogenic carcinoma:

- a. Definition: A malignant growth of abnormal epithelial cells arising in a bronchus classified into 4 types:

Table 1: Bronchogenic Carcinoma²

Type	Squamous Cell Carcinoma	Small Cell Carcinoma	Adenocarcinoma	Large Cell Carcinoma
Incidence of all Lung Cancers	50%	30%	15%	15%
Frequent Sites of Incidence	Majority are centrally located tumors	75% of the time arises in centrally located proximal lesion, often with lymph node involvement	Majority are peripherally located tumors	Majority are subpleural
Growth rate	Relatively slow	Extremely rapid	Moderate	Rapid
Metastatic Tendencies	Slow; to hilar lymph nodes, liver, adrenal gland, CNS, pancreas	Extremely rapid; to lymph nodes, CNS, liver, adrenal gland, pancreas	Moderate; to CNS, hilar and mediastinal lymph nodes	Rapid; to brain
Operability	Good	Almost none	Poor	Poor

I. Pleural Effusion

- a. Definition: The accumulation of fluid in the pleural space.
- b. Cause: Capillaries in the visceral pleura receive blood via low pressure pulmonary circulation while capillaries in parietal pleura receive blood via high pressure arterial circulation. When fluid formation and fluid reabsorption is not balanced, fluid accumulates in the pleural space which restricts the lungs from expanding fully. The fluid is either transudate or exudates. Transudate is fluid with low protein content which accumulates due to change in hydrostatic pressure within pleural capillaries. This can be caused by CHF, left ventricular failure, cirrhosis, pericardial disease, PE, peritoneal dialysis, or atelectasis. Exudate is fluid with high protein content which accumulates due to changes in permeability of pleural surfaces. This can be caused by parasitic or fungal infections, tuberculosis, bronchogenic carcinoma, or sarcoidosis.
- c. Signs and Symptoms: Tachycardia, dyspnea, increased respiratory rate
- d. Medical Management: Focus on treating the underlying cause will usually cause the pleural effusion to resolve. If it does not resolve a thoracentesis or chest tube is used to drain the effusion.

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J. Sarcoidosis

- a. Definition: Multisystem disease which is characterized by noncaseating epithelioid granulomas in many organs. The lung is the most involved organ.
- b. Cause: There is no known etiology of sarcoidosis.
- c. Signs and Symptoms: Dyspnea, cough, fatigue
- d. Medical Management: Focus is on suppressing alveolitis and granuloma formation via corticosteroids.

Cardiovascular Causes

A. Pulmonary edema

- a. Definition: An increase in the amount of fluid within the lung interstitial spaces and alveoli. This usually results when capillary filtration exceeds fluid removal.
- b. Causes: Caused by increased pulmonary capillary hydrostatic pressure secondary to left ventricular failure. This causes increased alveolar capillary membrane permeability as in ARDS^{2,3}.
- c. Signs and Symptoms: The hallmark symptoms of pulmonary edema are decreased breath sounds with wet wheezing, increased work of breathing, and pink frothy sputum as well as shortness of breath, cyanosis, and increased respiratory rate.
- d. Medical Management: Focus is on decreasing cardiac preload via venodilators, inotropic agents, and diuretics as well as optimizing ventilation with supplemental oxygen.

B. Pulmonary emboli (PE):

- a. Definition: Thrombi travel from systemic veins through the right side of the heart into pulmonary circulation where they lodge in branches of the pulmonary arteries. This creates a physiological dead space in which ventilation is in excess of perfusion and therefore the V/Q ratio is increased and perfusion cannot be completed due to blockage. PE stops the blood flow to certain areas of the lung leading to decreased or halted perfusion to pulmonary capillaries. This occlusion causes edema and hemorrhage into surrounding lung parenchyma and the lack of blood flow causes coagulative necrosis of alveolar walls. This causes an increase in alveolar dead space as a portion of the lung is being ventilated but not perfused.
- b. Cause: Most commonly caused by a lower extremity thrombus which is usually secondary to bedrest, long periods of travel, orthopedic surgery, or obesity.
- c. Signs and Symptoms: Acute onset of dyspnea, tachycardia, rapid shallow breathing pattern, cough
- d. Medical Management: Focuses on anticoagulation, supplemental oxygen, and in some cases pulmonary embolectomy for large PEs.

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Musculoskeletal Causes

- A. Diaphragmatic paralysis or paresis
 - a. Cause: Caused by a lesion in the neurological or muscular system. Unilateral paralysis or paresis is most commonly caused by injury of the phrenic nerve from bronchogenic carcinoma or surgical resection and open heart surgery.
 - b. Signs and Symptoms: Possible paradoxical breathing, decreased breath sounds in base of affected side, dyspnea, orthopnea, morning headaches secondary to decreased O₂ and increased CO₂ retention
 - c. Medical Management: If the lesion is bilateral then mechanical ventilation may be required.
- B. Kyphoscoliosis:
 - a. Definition: A combination of excessive anteroposterior and lateral curvature of the spine with angles 70-120 degrees. Decreased chest wall compliance causes increase in work of breathing and alveolar hypoventilation. Over time this can cause structural changes in the vessels and thickening of pulmonary arteriolar walls leading to cor pulmonale. Kyphoscoliosis greater than 120 degrees are associated with severe RLD and respiratory failure.
 - b. Cause: Kyphoscoliosis can be idiopathic, congenital or develops in response to a neuromuscular disease.
 - c. Signs and Symptoms: Decreased breath sounds over the compressed lung, DOE, decreased exercise tolerance, increased accessory muscle use, and hypoxemia.

Neurological Causes

- A. Spinal cord injuries (SCI)
 - a. Definition: Cervical injuries which result in inspiratory and expiratory muscles weakness or paralysis.
 - b. Cause: The cause of SCI is often traumatic such as a motor vehicle accident or diving accident.
 - c. Signs and Symptoms: If diaphragm use is retained, breathing dynamics are altered leading to paradoxical breathing.
 - d. Medical Management: Focus is on strength and endurance training of the remaining ventilatory muscles.
- B. Demyelinating Diseases
 - a. Definition: A demyelinating disease of the motor neurons of the peripheral nerves.
 - b. Signs and Symptoms: Rapid bilateral ascending flaccid motor paralysis, shortness of breath, and decreased breath sounds with 10-20% of patients developing acute respiratory failure.
- C. Progressive Degenerative Diseases
 - a. Definition: Progressive degenerative disease of the nervous system involving upper and lower motor neurons.
 - b. Signs and symptoms: Weakness of respiratory muscles, decreased breath sounds, progressive weakness beginning with hands and feet, DOE
 - c. Medical Management: Treatment focuses on comfort.

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D. Rib fractures

- a. Definition: The most commonly fractured ribs are 5-9 as these are less protected than ribs 1-4 and are anchored both anteriorly and posteriorly. Pain from rib fractures is what causes restrictive impairment as patients are reluctant to breathe deeply. Rib fractures may be accompanied by a hemothorax.
- b. Cause: Usually traumatic
- c. Signs and symptoms: Pain, shallow breathing, self-splinting on side of fracture
- d. Medical Management: Focus is on pain control.

E. Flail chest

- a. Definition: Anterior and posterior fracture of the same rib resulting in a free floating segment of the rib. This is often associated with lung contusion.
- b. Cause: Usually caused by blunt trauma.
- c. Signs and Symptoms: shallow breathing, decreased lung volumes, pain, chest wall deformity
- d. Medical Management: Mechanical ventilation may be required if patient's respiratory rate exceeds 40 breaths/min. With severe displacement of rib segments surgical stabilization may be required.

ICF model⁴

- Body Structure: s410 structure of cardiovascular system, s430 structure of respiratory system, s710 structure of head and neck region, s720 structure of shoulder region, s760 structure of trunk
- Body Function: b440 respiration functions, b445 respiratory muscle functions, b450 additional respiratory muscle functions, b455 exercise tolerance functions, b460 sensations associated with cardiovascular and respiratory functions, b450 additional respiratory functions, b740 muscle endurance functions
- Activity and Participation: d450 walking, d455 moving around, d230 carrying out daily routine, d640 doing housework, d540 dressing

Contraindications / Precautions for Treatment:

Understanding medical procedures, tests, lab values and oxygen delivery systems are important for PTs in the acute care setting in order to more accurately make a prognosis, determine a treatment plan, and make recommendations for oxygen delivery during functional activity.

Awareness of specific lines and tubes specific to patients with pulmonary disease is important for efficient and safe management during mobilization.

Oxygen Delivery Systems: ^{5,6}

- A. Nasal cannula (NC): NC is the most commonly used device and is intended to be used for O₂ flow rates 1-6 L/min. Humidification can be used as O₂ above 3-4L/min can cause dry nasal mucosa⁷.



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- B. Simple mask/Face Mask (FM): Beneficial for patients who are mouth breathers and is intended to be used with O₂ flow rates 5-10L/min. Humidification can be used as O₂ concentrations above 4L/min can cause dry nasal/oral mucosa⁸.



- C. Shovel Mask: Can be used for the administration of aerosolized medications and for administration of controlled percentages of O₂ at levels slightly higher than the simple mask (10-12L/min) or FiO₂ is regulated between 35-100%⁹.



- D. Venturi Mask: Provides greater flow of O₂ and combines room air with O₂. This is convenient as it can be converted to trach collar for portable delivery⁸.



- E. Non-rebreather mask (NRB): The mask and reservoir allows 60-80% FiO₂ or above 10 L/min. Humidification is not used as it would alter the percent of O₂ delivered⁸.



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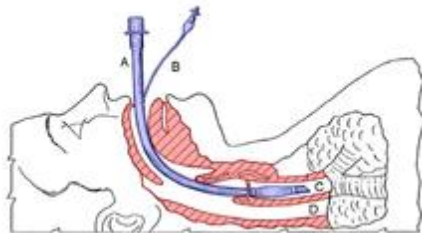
- F. Continuous positive airway pressure (CPAP): Provides one level of positive airway pressure (PAP) in order to maintain airway patency. CPAP is used as a treatment for sleep apnea¹⁰.



- G. Bilevel positive airway pressure (BiPAP): Provides pressure support with inhalation and a lower level of pressure support during exhalation. This decreases the work of breathing and reduces carbon dioxide (CO₂) retention by preventing airway collapse during exhalation. BiPAP can be portable, can consider using it with patients on non-rebreather¹¹.



- H. Endotracheal (ET) tube: An artificial airway inserted into the trachea that can be oral or nasal. It is usually a last resort effort when other means of ventilation have failed. The four primary reasons for utilizing an ET tube are upper airway obstruction, inability to protect the lower airway from aspiration, inability to clear secretions from lower airways, and a need for positive pressure mechanical ventilatory assistance¹².



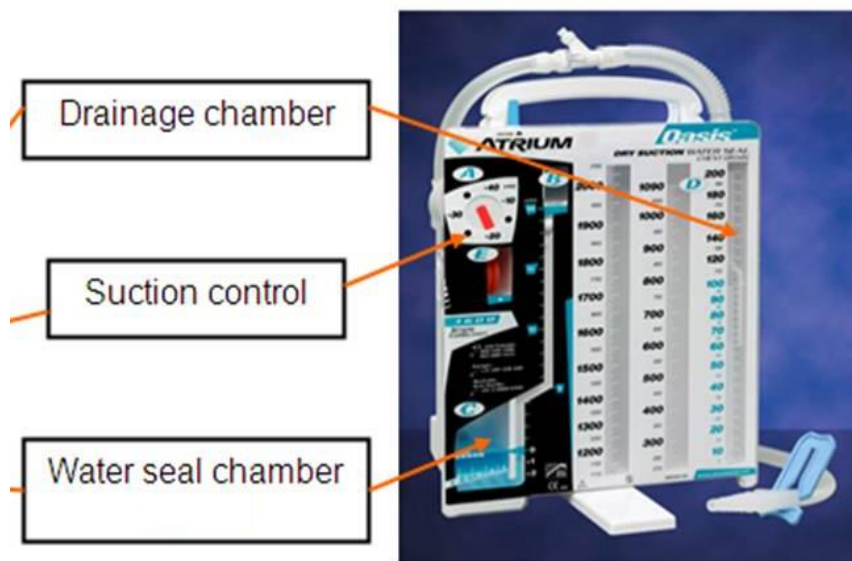
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- I. Tracheostomy tube: An artificial airway inserted into the trachea¹³.



Lines/Tubes/Drains¹⁴

- A. Pleural chest tube: Used to drain fluid, blood (hemothorax) or air (pneumothorax). The chest tube drainage unit consists of three chambers. The drainage chamber collects the chest drainage, the water seal chamber provides negative pressure for the chest tube unit. It permits air and fluid to exit the pleural space while preventing air from entering. The suction control chamber is connected to wall suction and should create a gentle bubbling.



- a) Considerations for PT: The chest tube drainage unit should be maintained in the upright position at all times so that the fluid can be measured. Chest tubes are removed based on how much they are draining so precise measurement is important. After a thoracic surgery, if a patient has a chest tube to suction it cannot come off of suction for mobility purposes. In this case extra suction tubing can be connected to the wall or for out of the room activity a portable suction unit can be used. These are usually located on the thoracic walkers.

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Surgical Procedures

- A. Bronchoscopy¹⁵: A flexible scope is used for diagnosis or treatment to directly visualize neoplasms, strictures, or stenosis and to suction the upper airway and tracheobronchial tree for removal of secretions, foreign bodies, or for bronchoalveolar lavage (BAL).
- B. Thoracentesis¹⁶: Percutaneous needle aspiration of pleural fluid. May be used as diagnostic test or therapeutic procedure to relieve respiratory distress caused by a large pleural effusion. A complication of the procedure may include a pneumothorax. On the day of the thoracentesis, consider scheduling physical therapy following the procedure and once the patient is cleared by chest x-ray, since the patient should be less dyspneic with exertion. Monitor oxygen saturation during PT treatment after thoracentesis.
- C. Video Assisted Thoracoscopic Surgery (VATS): Minimally invasive procedure usually requiring 3 small incisions for surgical instruments and camera. It is used for biopsy, wedge resection, lobectomy, and pleural resection.
- D. Wedge resection: Removal of lung parenchyma without regard to segment division (a portion of more than one segment but not a full lobe).¹⁵ This is the most common procedure for peripheral parenchymal carcinoma.
- E. Lobectomy: The resection of one or more lobes of the lung; this is the most common procedure for isolated lesions.¹⁵
- F. Pneumonectomy: The removal of an entire lung. This is the most common procedure for bronchial carcinoma, emphysema, multiple lung abscesses, bronchiectasis, tuberculosis, and mesothelioma.¹⁵
- G. Pleurectomy: The removal of part of the parietal pleura, the extrapleural pneumonectomy (EPP) is most commonly performed for mesothelioma. In this procedure a thoracotomy approach is used to perform a broad dissection involving the diaphragm and division of the pericardium in order to remove the lung, lymph nodes, and pleura. The diaphragm and pericardium are repaired during surgery.¹⁷
- H. Intraoperative Heated Chemo (IOHC): Chemotherapy agent is heated and administered to open chest cavity for 1-2 hours and then drained. This is often performed with an EPP.
- I. Pericardial window: Resection of an area of pericardium for the treatment of a pericardial effusion.¹⁸
- J. Claggett Window: Lateral incision with removal of several rib segments to create a “window”. An incision is made to deflect the skin and muscle. The ribs are resected and then muscle and skin are pulled down over the edges of the window. The wound is packed with solution soaked Kerlix to provide cleaning and promote tissue growth. The window is left open for 4-6 weeks allowing tissue growth and then is surgically closed with a muscle flap. This is used to treat empyema or bronchopleural fistula.
- K. Esophagectomy: The removal of a portion or the entire esophagus. This may be performed via cervical, transthoracic, or transhiatal incisions or laparoscopically (minimally invasive or Ivor-Lewis esophagectomy). The patient may require increased supplemental oxygen for up to 8 hours following the procedure and may have decreased activity tolerance.¹⁹
- L. Lung transplant: see to Standard of Care: Inpatient Management of the Patient Status Post Lung Transplant.

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Non-Procedure related

- A. New or Acute Pulmonary Embolism (PE): The following are signs and symptoms of a PE and are indicative of an emergent medical situation. Notify the RN/MD immediately if the patient develops rapid onset of tachypnea, anxiety, lightheadedness, tachycardia, chest pain, dysrhythmia, hypotension, decreased SpO₂. If you are treating a patient with a known PE, determine whether the patient is therapeutically anticoagulated prior to treatment. Generally patients will be started on Heparin with a bridge to Coumadin for long term anticoagulation.^{3,15,20}
- B. Anticoagulation: Therapeutic INR is 2.0-3.0. PTT can also be used to determine therapeutic anticoagulation. The reference range for PTT is 23-36 seconds and generally the goal for PTT is to be 60-80 seconds. An inferior vena cava (IVC) filter may be placed when patients are at high risk for developing a new or recurrent pulmonary embolism (PE) and/or cannot be anticoagulated. Patients are usually on bed rest for 4-6 hours after the procedure. Physical therapy may resume once activity orders are advanced. INR does not have to be within therapeutic range after the filter is placed.²¹
- C. Supratherapeutic INR: If the INR is 4.0-5.0 resistive exercise should be held. For INR greater than 5.0-6.0 exercise should be held but evaluation and continuation of the patient's current level of mobility is appropriate. The goals of therapy should be to determine discharge plan, maximize patient safety, and minimize the effects of bedrest. For INR greater than 6.0 bedrest or decreased level of activity should be considered. If the INR is not likely to be corrected quickly (within 2 days) a discussion with the team should take place to weigh the risks of bleeding against the risks of bedrest.²²
- D. Pneumothorax: Air enters the pleural space which decreases the natural negative pressure of the pleura causing the lungs to recoil or collapse.¹⁴ An open pneumothorax is when the pleural space is open to the atmosphere and air is able to move freely in and out of the pleural space through an opening in the chest. This is usually caused by trauma such as a gunshot wound, stab wound, or car accident. A closed pneumothorax is when the chest wall remains intact. Air enters the pleural space through a rupture of the lung and visceral pleura. A spontaneous pneumothorax occurs for no obvious reason.

Relevant Tests

- A. Pulmonary function tests (PFTs): A measure of flow rates, lung volumes, gas exchange and respiratory muscle function. Forced vital capacity (FVC) is a measure of maximal exhaled volume after a maximum inhale. Forced expiratory volume in 1 second (FEV₁) is a measure of the forced expiratory volume in the first second and is used in diagnosing and monitoring pulmonary disease. FEV₁ is decreased in obstructive disease. The FEV₁/FVC ratio is decreased in obstructive disease and normal or increased in restrictive disease. Pulmonary disease is classified as obstructive if the FEV₁/FVC ratio is less than 70% of predicted norms. Pulmonary disease is classified as restrictive if the FEV₁/FVC ratio is greater than or equal to 80% of predicted norms.²³
- B. Arterial blood gas (ABG): PaO₂ is the partial pressure of dissolved O₂ in plasma with a normal range of >80mmHg. PaCO₂ is the partial pressure of dissolved CO₂ in plasma with a normal range of 35- 45 mmHg. pH is the degree of acidity or alkalinity in the blood with a normal range of 7.35-7.45. HCO₃ is the level of bicarbonate in the blood with a normal range of 22-28mEq/Liter. It is typically documented as PaO₂/PaCO₂/pH/HCO₃. The interpretation of ABGs can be broken down into a few steps. First determine if the pH, pCO₂, and HCO₃ are acidotic or alkalotic. First look at

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the pH; if under 7.35 it is acidotic, if over 7.45 it is alkalotic. Next look at the pCO₂; if under 35 it is alkalotic, over 45 it is acidotic. Last look at the HCO₃; if under 22 it is acidotic, if over 26 it is alkalotic. After determining if these are acidotic or alkalotic, match the pH with either CO₂ or HCO₃. If both the pH and the CO₂ are acidotic then it is respiratory acidosis. If the pH and the HCO₃ are both acidotic then it is a metabolic acidosis. Conversely if the pH and CO₂ are both alkalotic then it is respiratory alkalosis. If the pH and HCO₃ are both alkalotic it is metabolic alkalosis. The next step is to look to see if the CO₂ or HCO₃ go in the opposite direction of pH; if so there is compensation by that system (respiratory or metabolic). For example if the pH is acidotic, the CO₂ is acidotic, and the HCO₃ is alkalotic then this indicates respiratory acidosis with partial compensation by metabolic alkalosis.^{24,25}

Evaluation:

Past Medical History (PMH): All relevant past medical and surgical history. In patients with respiratory disease it is important to note the type of disease, the onset/duration of disease, any past procedures specifically related to the disease. Include any diagnosis that may have an impact on the patient's functional or respiratory status.

History of Present Illness (HPI): Reason for admission including chief complaint, onset and duration of pertinent symptoms such as increased DOE, change in sputum production, recent PFTs, recent hospitalizations and any relevant events leading up to the hospitalization including any outside hospital information.

Hospital Course: May include BWH emergency department (ED) course, medical workup and treatments, procedures and complications, supplemental oxygen requirements, any significant changes in vital signs or labs, dates of extubation, ventilator weaning, sedation weaning, consulting services and recommendations, and reason for PT consult.

Social History: Information regarding a patient's home environment, current/potential barriers to returning home, family or caregiver support, occupation, history of tobacco use, asbestosis exposure and any other family, professional, social, or community roles as appropriate. It is also important to ascertain the patient's goals and expectations of returning to previous life roles. For patients with respiratory disease, this may also include any prior participation in a pulmonary rehab program, recent rehab stays, or home services.

Prior functional and endurance level: Patient's typical daily routine, ability to complete activities of daily living (ADLs) or instrumental activities of daily living (IADLs), participation in any exercise routines or programs, history of falls. In this population is important to ask specific questions regarding their baseline endurance level and O₂ requirements. Some examples of specific questions are: What are your O₂ needs at home both at rest and with activity? What is your home O₂ setup and who manages it? How far are you able to walk in the house without having to sit down because of shortness of breath? Do you have to sit down to perform any activities at home such as brushing your teeth or preparing meals? If you do these things standing up do you find yourself to be short of breath?

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Medications: 15,26

- A. Bronchodilators: beta-adrenergic, xanthine derivative, anticholinergic
 - a. Primary use: To relieve bronchospasm associated with obstructive pulmonary disease, asthma and exercise induced bronchospasm.
 - b. Mechanism of Action:
 - i. Anticholinergics: Blocks action of acetylcholine in bronchial smooth muscle causing bronchodilation. Examples include Atrovent and Spiriva.
 - ii. Beta 2 agonists: Relaxes bronchial smooth muscle by acting on beta 2 receptors located in bronchiole smooth muscle with little effect on heart rate as predominant effect on cardiac tissue is mediated via beta 1 receptors. These are short acting and are commonly referred to as “rescue” inhalers. Examples include Albuterol, Epinephrine and Salmeterol.
 - c. Implications for PT: The use of a bronchodilator immediately before PT intervention will increase the patient’s tolerance to activity and increase their ability to clear secretions. Depending on the specific medication it should be administered within 30 minutes prior to initiation of therapy and are effective for 1-12 hours.
- B. Glucocorticoids (corticosteroids):
 - a. Primary use: To stabilize and limit bronchoconstriction of the airways in patients with asthma and COPD.
 - b. Mechanism of Action: Inhibits the production of pro inflammatory products while also increasing production of anti inflammatory proteins. Examples include Dexamethasone, Prednisolone, Prednisone, Hydrocortisone and Cortisone.
 - c. Implications for PT: Long term use of corticosteroids can cause proximal muscle weakness and osteoporosis²⁷
- C. Leukotriene Inhibitors:
 - a. Primary use: Used for long term control of asthma and COPD as they decrease inflammation.
 - b. Mechanism of Action: Decreases inflammation of respiratory tissues by blocking leukotriene receptors on respiratory cells. These are usually used in conjunction with glucocorticoids as they enhance the anti-inflammatory properties of glucocorticoids. Examples include Zyflo, Singulair, and Accolate.
 - c. Implications for PT: side effects include fatigue, nausea, vomiting
- D. Mucolytics:
 - a. Primary use: Decreases the viscosity of respiratory secretions.
 - b. Mechanism of Action: degrade disulfide binds in mucus making mucus less viscous. Examples include Mucomyst and Mucosil.
 - c. Implications for PT: If taken before PT, they may assist in airway clearance.
- E. Expectorants:
 - a. Primary use: Facilitation and ejection of mucus
 - b. Mechanism of Action: Increases the secretion of thin watery mucus in upper airways. Examples include guaifenesin.
 - c. Implications for PT: If taken before PT, they may assist in airway clearance.

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- F. Cromones:
 - a. Primary use: These are usually administered prophylactically to prevent bronchospasm which is initiated by specific activities such as exercise and exposure to allergens in patients with asthma.
 - b. Mechanism of Action: Inhibits the release of inflammatory mediators. Examples include Intal, Nasalcrom, Tilade.
 - c. Implications for PT: If a patient experiences exercise induced asthma it will be helpful for the patient to utilize this medication within 30 minutes of initiation of PT session.
- G. Antitussives:
 - a. Primary use: Suppresses ineffective, dry coughing associated with common cold or minor throat irritations.
 - b. Mechanism of Action: Blocks overly active receptors or increases the threshold for cough center in the brain. Examples include Codeine and Dextromethorphan.
 - c. Implications for PT: may be helpful before activity if the cough is limiting patient's function.
- H. Decongestants:
 - a. Primary use: Relieves upper respiratory congestion and mucous discharge.
 - b. Mechanism of Action: Causes vasoconstriction in mucosal vasculature by stimulating alpha receptors. Examples include Ephedrine, Afrin, Phenylephrine, and Pseudoephedrine.
 - c. Implications for PT: side effects include cardiac irregularities, HTN, dizziness
- I. Antihistamines:
 - a. Primary use: Decreases inflammation and bronchoconstriction associated with hypersensitivity reactions such as allergic rhinitis.
 - b. Mechanism of Action: Block H receptors in order to decrease mucosal congestion and irritation. Examples include Zyrtec, Benadryl, Claritin and Allegra.
 - c. Implications for PT: May be helpful before activity to reduce symptoms, can usually be taken every 4-8 hours.

Examination

- A. Subjective: This is a good time to note whether the patient has 1-2-3 word dyspnea
- B. Observation: Lines and tubes (specifically chest tubes method of oxygen delivery and amount), patient position and appearance.
- C. Posture: Barrel chest is increased anterior/posterior diameter of the chest commonly seen in patients with COPD. Pectus excavatum is a congenital deformity of the chest in which the sternum caves in and in severe cases can effect respiration. Pectus carinatum is a deformity of the chest in which the sternum and ribs protrude outwards. Kyphosis is an overcurvature of the thoracic spine, scoliosis is an irregular lateral curvature of the spine. Shoulder position should also be noted such as rounded or elevated.
- D. Cognition/Mental Status: Level of alertness, ability to follow motor commands, level of safety awareness, emotional lability, learning style and learning barriers. Consider screening with RASS²⁸, CAM²⁹, or consultation of Occupational Therapy.

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- E. Pain: Location and severity before, during and after physical therapy intervention with a numeric rating scale or visual analog scale (VAS) 0-10³⁰ including documentation of how you responded to the reported pain (e.g., informed nurse).
- F. Pulmonary:
 - a. Breath sounds via auscultation

Table 2: Breath Sounds^{1,2,15}

Sound	Location	Sound Quality	Distinguishing Characteristic
NORMAL SOUNDS			
Vesicular	Periphery of lungs	Soft, low pitched, gentle rustling	Inspiration longer and louder than expiration without pause
Bronchial	Sternum/manubrium	Loud, high-pitched; hollow pipe sound	Expiration longer and louder than inspiration with a pause
Bronchovesicular	1 st and 2 nd intercostal space (ICS) and between scapulae (near mainstem bronchus)	Medium pitched	Inspiration and expiration equal in length and loudness
Tracheal	Over the trachea	Loud, harsh	Expiration slightly longer than inspiration with similar loudness
ADVENTITIOUS SOUNDS			
Crackles (rales)	Over lungs with disease or disorder	Soft, high pitched, discontinuous	Early during inspiration: bronchitis, emphysema, asthma; Late during inspiration: interstitial lung disease, pulmonary edema
Wheeze	Over lungs and constricted airways	High pitched, continuous	Heard most often during expiration but can be heard during inspiration; result of airway constriction
*Normal sounds can be adventitious if they are heard in areas other than those noted above			

- b. Voice Sounds: If consolidation is suspected voice tests can be performed to confirm this. For whispered pectoriloquy the patient whispers “1, 2, 3”. The test is positive for consolidation if the phrase is heard clearly in the distal lung fields. For bronchophony the patient says “ninety nine” repeatedly. The test is positive for consolidation if the phrase is heard clearly in the distal lung fields. For egophony the patient says “e” repeatedly. The test is positive for consolidation if the letter “a” is heard in the distal lung fields.

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- c. Breathing pattern: Note the rate, rhythm, depth, and inspiration:expiration ratio, if the patient appears comfortable, in distress, flaring nostrils, or use of accessory muscles.

Table 3: Breathing Pattern^{1,2}

Breathing Pattern	Description
Fish-Mouth	Apnea with associated mouth opening and closing
Eupnea	Normal rate and depth, regular rhythm
Bradypnea	Slow Rate, shallow or normal depth, regular rhythm
Tachypnea	Fast rate, shallow depth. Regular rhythm
Hyperpnea	Normal rate, increased depth, regular rhythm
Prolonged Expiration	Fast inspiration, slow expiration, normal rate, depth and regular rhythm; associated with obstructive lung disease
Orthopnea	Difficulty breathing in postures other than erect
Dyspnea	Rapid rate, shallow depth, regular rhythm; associated with accessory muscle activity
Abdominal Paradox	Upward and outward motion of upper chest, inward motion of abdomen (seen in flail chest where disconnected segment of ribs moves inward during inspiration and outward during expiration)
Upper Chest Paradox	Upward and outward motion of abdomen and inward motion of upper chest
Excessive Accessory Muscle Use	Excessive upper chest motion with increased use of SCM, scalenes, other accessory muscles of inspiration

- d. Chest wall movement: Observe chest wall motion in superior, middle, inferior, anterior and posterior lung fields in both quiet and deep breathing. For superior lobes place hands over clavicles, for middle place hands at lateral ribs, for posterior place hands over scapulae. Note asymmetry and difference in motion in different areas. Make sure to look at entire chest wall motion as well as segmental motion to fully assess problematic areas.

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- e. Cough: A forceful exhalation with a closed glottis. A cough is different from a huff which is a forceful exhalation with an open glottis.

Table 4: Cough Characteristics ^{1,2}

COUGH CHARACTERISTICS	DESCRIPTORS
Strength	Strong, moderate, weak
Quality	Productive, non-productive, dry, persistent, violent, brassy, wheezy
Depth	Shallow, deep
Secretions	Minimal, copious, thick, thin, color, frothy, mucoid, blood-tinged, foul smelling, hemoptysis
SECRETION DESCRIPTION	HALLMARK DISEASE
Purulent and foul smelling	Bronchiectasis, lung abscess
Rust colored and purulent	Pneumococcal pneumonia
Currant Jelly consistency or sticky	Klebsiella pneumonia
Blood-tinged and frothy	Pulmonary edema

- G. Cardiovascular: Vital Signs before, during, after PT; specifically SpO₂ and RR.
- a. Endurance³¹: 6 Minute Walk Test (6MWT) worksheet is available on the T drive to calculate gait speed, METs, predicted distance, % predicted distance. For Rate of Perceived Exertion (RPE) use the Modified Borg Scale and for Dyspnea on Exertion (DOE) use the Modified Borg Rating for Perceived Dyspnea.
- H. Neuromuscular: Comment on coordination, proprioception, tone, sensation, and balance. Use a functional balance assessment (e.g. Tinetti Balance Test, Berg Balance Test, Dynamic Gait Index, Timed Up and Go) when possible. Gross sitting and standing statements may be used if patients are unable to perform standardized test.
- I. Integumentary: Include surgical incisions, edema, presence of ulcers, skin quality, digital clubbing, cyanosis.
- J. Musculoskeletal: ROM, specifically of shoulders and ribs and strength which should include functional assessment and manual muscle testing. Specifically note inspiratory and expiratory muscle weakness. Expiratory muscle weakness can cause an inability to cough and increase pulmonary infections. Inspiratory muscle weakness can cause hypoxemia, hypercapnia, and atelectasis.

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Assessment:

Diagnosis: Identify a physical therapy diagnosis, if different from medical diagnosis, and rationale. Identify the need for skilled physical therapy services, e.g. maximize patient functional safety and/or independence in home setting.³² The following are a list of potential practice patterns that this patient population may fall into according to the *Guide to Physical Therapy Practice*: 6A Primary prevention/risk reduction for cardiovascular/pulmonary disorders; 6B Impaired aerobic capacity/endurance associated with deconditioning; 6C Impaired ventilation, respiration/gas exchange and aerobic capacity/endurance associated with airway clearance dysfunction; 6E Impaired ventilation and respiration/gas exchange associated with ventilatory pump dysfunction or failure; 6F Impaired ventilation, respiration/gas exchange associated with respiratory failure.

Problem List³³

Table 5: Problem List

Body Structure or Function	Activity Restriction	Participation Restriction
<ul style="list-style-type: none">• Incisions• Pulmonary system impairment• Cardiac system impairment• Skin integrity• ROM impairment• Breathing pattern impairment• Impaired ventilation• Impaired airway clearance• Cardiovascular and pulmonary system deconditioning• Decreased aerobic capacity• Decreased strength• Impaired balance• Impaired sensation• Pain	<ul style="list-style-type: none">• ADLs• Ambulation• Transfers• Bed mobility• Stair negotiation	<ul style="list-style-type: none">• Ability to live independently• Social activities• Working• Driving• Sporting activities

Prognosis: The prognosis may be influenced by contextual factors e.g. patient motivation, prior experience with this condition, architecture of home (stairs, ramps, grab bars, etc.), support network (family or friends), extent and progression of lung disease, ongoing medical or surgical treatments or interventions, presence of co-morbidities, age, prior level of function. The medical prognosis of patients should be taken into consideration when making realistic achievable goals for patients with pulmonary disease.

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Goals: PT goals for patients with primary pulmonary pathology include promoting functional independence, maximizing gas exchange, increasing aerobic capacity, respiratory muscle endurance and patient's knowledge of the condition and management.¹⁵

A. Examples of short term goals:

- a. Demonstrate independent pacing and monitoring of fatigue and/or SOB
- b. Demonstrate independent exercise and endurance program
- c. Maintain SpO₂ > 95%* at rest on least amount of supplemental oxygen(* or SpO₂ as indicated by MD orders)
- d. Maintain SpO₂ > 92%* with activity on least amount of supplemental oxygen(* or SpO₂ as indicated by MD orders)
- e. Report moderate or less effort (or RPE <3/10) with all functional activities
- f. Improved distance on two, six or twelve minute walk test
- g. Independent with breathing exercises to maximize ventilation
- h. Independent with breathing techniques during activity to maximize ventilation (such as pursed lip breathing, paced breathing etc.)
- i. Independent with airway clearance

Treatment Planning / Interventions

Established Pathway ___ Yes, see attached. X No

Established Protocol ___ Yes, see attached. X No

Pulmonary Specific Interventions^{1,2,15}

Airway Clearance Techniques: manual or mechanical procedures that facilitate mobilization of secretions from the airways. This is indicated for patients with impaired mucociliary clearance, excessive pulmonary secretions, and ineffective or absent cough. An inhaled bronchodilator given prior to airway clearance will optimize the intervention.

- A. Postural Drainage (PD): Assumption of specific body positions that allows gravity to assist with draining secretions. This can be used alone or in conjunction with other techniques such as percussion, vibration and shaking. The most affected lung segments should be treated first and the patient should be encouraged to take deep breaths while in the PD position and encourage coughing between positions. Continuous tube feeding should be interrupted during airway clearance if patient is being fed via NG tube as positions in which if the head is lowered may cause aspiration. If patient is being fed via G tube or J tube this is not a concern as the tube is directly inserted into the stomach (G tube) or jejunum (J tube).

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- B. Percussion: Loosening of secretions either manually or with a mechanical device. It is most effective if performed in conjunction with PD positions. Manual percussion consists of rhythmic clapping with cupped hands over the affected lung segments. Clapping over bony prominences and surgical incisions should be avoided. Mechanical percussion devices such as the Vest are electrically or pneumatically driven. Precautions include anticoagulation, osteoporosis, rib fractures, metastatic cancer to the ribs, recent pacemaker placement, and uncontrolled bronchospasm. Contraindications include unstable hemodynamic status, open wounds on the thoracic area, PE, subcutaneous emphysema, or recent skin grafts over thorax.
- C. Vibration: Loosening of secretions either manually or with a mechanical device which is most effective if performed in conjunction with PD positions. Manual percussion is performed with the palmar aspect of the PT's hands in full contact with patient's chest wall. The patient takes a deep inspiration and on expiration the PT's hands provide a downward pressure with quick oscillations. This is performed until secretions are mobilized or as long as the patient is able to tolerate it. Mechanical vibration may be more difficult to coordinate with patient's breathing cycle.
- D. Acappella and Aerobika: These devices provide positive expiratory pressure as well as oscillations upon exhalation. The amount of expiratory pressure is adjustable. The patient takes a deep inhalation and exhales into the device which may stimulate coughing.
- E. Active Cycle of Breathing: Forced expiratory technique based on optimal airflow and avoidance of a cough which can be performed in any position. The patient performs quiet breathing for a few breaths followed by a mid to large inhalation which is then huffed out. The cycle is repeated multiple times. Huffing may be sufficient to clear secretions or patient may feel the need to cough in order to clear secretions
- F. Autogenic Drainage: Controlled breathing to help clear secretions consisting of 3 parts. Unsticking mucus is low level lung breathing. This is done by inhaling a normal breath, holding for 1-3 seconds and then exhaling completely. This is repeated for 1-3 minutes or until crackles are heard on exhalation. The next step is collecting mucus. The patient takes a slightly deeper breath, holds for 1-3 seconds and exhales but not as deeply as in previous step. This is repeated for 1-3 minutes or until crackles are heard. Evacuating is the last step in which the patient takes a slow deep breath and holds for 1-3 seconds and forcefully huffs air out.
- G. Mechanical Aids for Coughing: devices and techniques involving manual or mechanical application of forces to the body or intermittent pressure changes to the airways in order to assist inspiratory and expiratory muscle function. Inspiratory aids provide air under pressure during inhalation (intermittent positive pressure ventilation). Expiratory aids provides negative pressure to the airway during expiration. An abdominal thrust can be applied during expiration.

Breathing Strategies: Techniques to maximize ventilation

- H. Pursed lip breathing: used to decrease dyspnea by slowing respiratory rate, decreasing resistive pressure drop across airways which decreases airway collapse during expiration (which occurs in COPD). Patient inhales through the nose with mouth closed and then exhaled slowly through pursed lips. This is indicated for patients with dyspnea at rest and/or with exertion, or wheezing.

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- I. **Paced Breathing:** volitional coordination of breathing during activity. Patient breathes in at the beginning of activity and out during the activity. This can be combined with pursed lip breathing or diaphragmatic breathing. It is indicated for patients with low endurance, dyspnea on exertion (DOE), fatigue, anxiety, and tachypnea.
- J. **Inspiratory Hold Technique:** prolonged holding of the breath at maximum inspiration. This keeps alveoli inflated and allows redistribution of oxygen to alveoli with different time constraints and through the pores of Kohn. Patient breathes in maximally and holds breath for 2-3 seconds with relaxed exhalation. This can be combined with vibration to assist in airway clearance. It is indicated for patients with hypoventilation, atelectasis, and ineffective cough.
- K. **Stacked Breathing:** A series of deep breaths which build on the previous breath without expiration until maximum inspiratory volume is reached. Each inspiration is followed by a brief inspiratory hold. Sniffing may be used to help facilitate learning of this technique. This keeps alveoli inflated but also slowly increases inspiratory volume to keep pain levels low while increasing ventilation. This is indicated for patients with hypoventilation, atelectasis, ineffective cough, pain, or an uncoordinated breathing pattern.
- L. **Diaphragmatic Breathing:** Outward motion of the abdominal wall while reducing upper rib cage motion during inspiration. This is used to decrease accessory muscle use. It can be used in any position although may be easiest to learn in supine or semi-Fowler position with posterior pelvic tilt with patient's hands on their own abdomen for tactile feedback. Sniffing may be used to help facilitate learning of this technique. Instruct the patient to sniff 3 times and exhale slowly. Progress patient to 1 slow sniff and repeated until patient is breathing in a relaxed manner. The scoop technique may also be used to help facilitate learning diaphragmatic breathing. In this technique the patient is in side-lying or semi-Fowler position with posterior pelvic tilt. On exhalation the PT scoops their hand up and under the patient's anterior thorax while instructing the patient to "breath into my hand". This is indicated for patients with hypoxemia, tachypnea, atelectasis, anxiety, and excess pulmonary secretions.
- M. **Lateral Costal Breathing:** Promotes intercostal expansion during inspiration. This can be used unilaterally or bilaterally. The patient is side-lying on uninvolved side with UE abducted overhead and the PT gives a stretch to intercostals before inspiration and then continues to hold pressure during inspiration. This can also be performed seated for bilateral intercostals and combined with bilateral UE abduction. For bilateral impairment the PT gives pressure to bilateral ribs before and during inspiration. This is indicated for patients with asymmetrical chest wall expansion, localized lung consolidation or secretions, asymmetrical posture, and shallow respirations.
- N. **Upper Chest Inhibiting Technique:** Inhibiting the upper chest can help the patient recruit the diaphragm during inspiration. This should be used only after other techniques have been attempted. The patient is side-lying or supine and the PT performs the scoop technique with one hand while the other hand rests on the patient's chest. The PT's hand follows patient's chest to expiratory resting position and does not move during inspiration providing a downward pressure on the chest. This is indicated for patients with excessive use of accessory muscles during breathing

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- O. Thoracic Mobilization Techniques: Increases the ability of the thorax to expand during breathing. Simple positioning can be very effective for this technique. For anterior chest wall mobility place a towel roll vertically along the thoracic spine while patient is in supine. For lateral chest wall mobility place a towel roll or pillows horizontally under the ribs while patient is in sidelying. The arm can be flexed or abducted overhead to further facilitate the stretch. This is indicated for patients with impaired chest wall mobility, hypoventilation, paradoxical breathing, impaired trunk muscle performance or tightness, ineffective cough.
- P. Butterfly: The patient sits unsupported with the PT standing either in front or behind. The PT assists patients to abduct shoulders into butterfly position while breathing audibly with the patient. During inspiration the arms are brought into further abduction, during expiration they are lowered. The PT slows their breathing pattern and arm movement gradually. This is indicated for patients with impaired chest wall mobility, hypoventilation, impaired trunk muscle performance or tightness, and ineffective cough.

Strengthening Strategies:

- A. Inspiratory Muscle Training (IMT): Increasing ventilatory capacity and decreasing dyspnea through strengthening and endurance training of inspiratory muscles.
 - a. Early stage strengthening consists of sniffing technique (see Diaphragmatic Breathing above). Straws can be used for light resistance. The patient inhales slowly through a straw without causing dyspnea. The next stage is resisted inhalation in which the PT places their hands below the patient's ribs on either side of the thorax. Before inspiration PT gives a small amount of resistance to the diaphragm by pushing up and in throughout inspiration; no resistance is given during expiration. Weights can also be used in this method but the PT must ensure that the patient is able to maintain comfortable breathing without the use of accessory muscles. Patients with poor strength will find strengthening in sitting difficult, the supine position prevents the abdominal contents from pushing into the diaphragm therefore allowing further abdominal excursion. The Quality of contraction should be monitored throughout the session as the patient should not be "pushing" with their abdominal muscles.
 - b. Handheld training devices produce resistance by decreasing the radius of the device's airway. The patient inhales through the device at a level that does not induce adverse effects such as dyspnea, or decreased O₂ saturation. This is indicated for patients with intact lungs such as patients with neuromuscular disease or patients on mechanical ventilation trying to wean off of the ventilator.
 - c. Deep Breathing Exercises involve the use of incentive spirometer 10x/hour with a focus on slow, deep, diaphragmatic breathing. This is indicated for patients with atelectasis. Incentive spirometers are not used at BWH but the same principles can be used without a device.

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Frequency & Duration

Patients will have follow-up physical therapy treatments based on individual need. The frequency of treatment for each patient will be determined by the potential for gains with skilled therapy, the acuity of the medical condition, and the ability of the patient to complete an activity/exercise prescription independently or with the assistance of other healthcare staff members. Refer to *the BWH Guidelines for Frequency of Physical Therapy Patient Care in the Acute Care Hospital Setting, Cardiovascular/Pulmonary Practice Pattern*.

Patient / family education

It is the role of a physical therapist to discuss realistic expectations regarding function, appropriate level of assist that the patient requires from family, and anticipated rehabilitation progression. Often this entails providing emotional support to the patient and family as needed. Education of conceptual ideas, e.g. energy conservation; self monitoring; exercise/activity related interventions, exam findings, airway clearance techniques, and recommendations for discharge is important. The department has the following handouts available for those with visual learning styles: individualized home exercise programs, What You Need to Know about Exercise and Activity after Thoracic Surgery, Energy Conservation for Patients and Families.

Recommendations and referrals to other providers:

Discuss the patient's need for additional services with the primary team. A patient may benefit from the following services if appropriate:

- A. Occupational Therapy: Appropriate for a patient who presents with cognitive or perceptual impairments, UE weakness or tone, or any other impairment that affects his or her ability to perform activities of daily living independently or for a patient who has UE splinting and/or adaptive equipment needs.
- B. Speech and Swallowing: Appropriate for a patient who presents with impairments that affect his or her ability to swallow without difficulty and/or who presents with a new language impairment.
- C. Respiratory Therapy: Appropriate for a patient with bronchopulmonary hygiene needs and complicated oxygen delivery needs beyond the typical set-up available on the patient care floor. The respiratory therapists are also responsible for all ventilator care and may be able to assist with ambulating patients on portable ventilators who are appropriate to do so.
- D. Care Coordination: Appropriate for a patient who has a complicated discharge situation and the care coordination team is not already involved.
- E. Social Work: Appropriate for a patient who has a complicated social history and he or she requires additional support or counseling; coping with prolonged hospital admissions
- F. Chaplaincy: Appropriate if a patient requires spiritual support or counseling.
- G. Nutrition: Appropriate for a patient who would benefit from counseling and recommendations for adequate nutrition while at BWH.

Re-evaluation:

Re-evaluation will occur when current short term physical therapy goals have been met and the patient still has skilled PT needs, significant change in medical status occurs, and/or within 10 days from the previous evaluation.

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Discharge Planning:

Commonly expected outcomes at discharge

Discharge planning will occur on an individual basis depending on the patient's medical, physical and social needs and is a coordinated effort that occurs with the physician, nurse, care coordinator, therapist(s), the patient and his or her family.

Transfer of Care

If further physical therapy treatment is warranted, recommendations will be provided to the patient, family, and physician team for appropriate additional rehabilitation services once discharged from the acute care setting. For example, if the patient has significant impairments and functional limitations and/or complicated medical needs at the time of discharge from the acute care hospital, he or she may be discharged to an acute or sub-acute rehabilitation facility, skilled nursing facility, or other extended care facility. Patients are frequently discharged with home O2 and the PT may be asked for recommendations regarding how much O2 a patient requires with activity. Home PT may be recommended for patients who require a home safety evaluation, have not met their short-term goals, or to address ongoing body impairments or activity/participation restrictions. Outpatient PT may be recommended for patients who have continued body impairments or activity/participation restrictions and who are able to leave their house.

Outpatient Pulmonary Rehabilitation

May be appropriate for patients with ongoing aerobic or activity tolerance limitations. This is a multidisciplinary intervention designed to reduce symptoms, optimize functional status through exercise, education, psychosocial and outcomes assessment. It provides further education in a group setting which can be very supportive for patients with chronic disease. The diagnoses approved for pulmonary rehab are COPD, emphysema, chronic bronchitis, bronchiectasis, sarcoidosis, pulmonary hypertension, pulmonary fibrosis, interstitial lung disease, lung cancer and lung cancer surgery, lung volume reduction surgery before and after lung transplantation. Information regarding pulmonary rehabilitation locations can be found here:

<http://www.aacvpr.org/Resources/SearchableProgramDirectory/tabid/113/Default.aspx>

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