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PULMONARY/CARDIAC/ CANCER REHABILITATION

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PULMONARY REHABILITATION

GOALS OF PULMONARY REHABILITATION

- Improvement in cardiopulmonary function
- Prevention and treatment of complications
- Increased understanding of the disease
- Increased patient responsibility for self-care and compliance with medical treatment
- Improvement in level of activity and quality of life, return to work

🕮 BENEFITS OF PULMONARY REHABILITATION

- Improvement in exercise tolerance, symptom-limited oxygen consumption, work output, mechanical efficiency, and vital capacity
- 🕮 Exercise increases arterial venous oxygen (AVO_2) difference, increasing oxygen extraction from arterial circulation
- Reduction in dyspnea and respiratory rate
- Improvement in general quality of life; decreased anxiety and depression, improvement in Activities of Daily Living (ADLs)
- Improvement in ambulation capacity
- Decreased hospitalization rates
- Focus on conditioning peripheral musculature in order to improve their efficiency and reduce stress on the heart and lungs (Alba 1996)

CANDIDATES FOR PULMONARY REHABILATION

Motivated nonsmokers or patients who have quit smoking and whose activities are limited because of dyspnea are good candidates for a pulmonary rehabilitation program.

- Functional evaluation to assess pulmonary disability is recommended prior to starting the program:

🕮 **Classification of functional pulmonary disability—Moser Classification**

1. Normal at rest—dyspnea on strenuous exertion
2. Normal ADL performance—dyspnea on stairs/inclines

3. Dyspnea with certain ADLs, able to walk one block at slow pace
4. Dependent with some ADLs; dyspnea with minimal exertion

Note: 1—4 have no dyspnea at rest

5. Housebound—🕮 dyspnea at rest, assistance with most ADLs

- 🕮 Patients who benefit the most from a pulmonary rehabilitation program have at least one of the following:
  - Respiratory limitation of exercise at 75% of predicted maximum O_2 consumption
  - Irreversible airway obstruction with a Forced Expiratory Volume in one second (FEV_1) < 2000 ml or an FEV_1/FVC ratio of less than 60% (See Lung Volume Definitions below)
  - Restrictive lung disease or pulmonary vascular disease with carbon monoxide diffusion capacity <80% of predicted value (Bach, 1993)

QUICK REVIEW OF PULMONARY PHYSIOLOGY

Central control of respiratory function

Voluntary control of respiration originates in the cortex and descends through the spinal cord to the respiratory muscles

The medullary respiratory center—serves to integrate different chemoreceptors

Central chemoreceptors (stimulated by hypercarbia)
Peripheral chemoreceptors (stimulated by hypoxia) located in the carotid and aortic bodies

Muscles of respiration

Inspiratory muscles

- Accessory muscles of respiration—sternocleidomastoid, trapezius, pectoralis major
- 🕮 Diaphragm—innervated by the phrenic nerve. Works at rest. Primary muscle of respiration
- External intercostals—act during exercise

Expiratory

- Abdominal muscles—primary expiratory muscles
- Internal intercostals

Muscles of the upper airway

- Keep the upper airway open
- Include muscles of the mouth, tongue, uvula, palate, and larynx

Acute ventilatory failure may result from

- Severe respiratory infections
- Pulmonary edema
- Diffuse parenchymal injury
- ARDS (Acute Respiratory Distress Syndrome)
- Acute pulmonary circulatory failure (i.e., acute pulmonary embolism)
- Head trauma or medications that can cause dysfunction of respiratory drive
- Patients with SCI with lesions above C3 present with diaphragmatic failure

Note: Chronic respiratory failure—considered when ventilatory failure exceeds 30 days

Pulmonary function evaluation

- The magnitude of functional impairment can be assessed through the use of pulmonary function tests
- Respiratory excursions during normal breathing and during maximal inspiration and expiration are observed

– Evaluation of lung volume changes can be used to classify respiratory dysfunction into obstructive and restrictive pulmonary disease

Lung Volume Definitions (Figure 9–1)

Vital capacity (VC): the greatest volume of air that can be exhaled from the lungs after maximum inspiration

Forced vital capacity (FVC): vital capacity measured with the subject exhaling as rapidly as possible

Total lung capacity (TLC): amount of gas within the lungs at the end of maximal inspiration

Tidal volume (TV): amount of gas moved in normal inspiratory effort

Functional residual capacity (FRC): amount of gas in the lungs at the end of normal expiration

Residual volume (RV): amount of gas in the lungs at the end of maximal expiration

Forced expiratory volume in one second (FEV_1): amount of air expelled in the first second of FVC

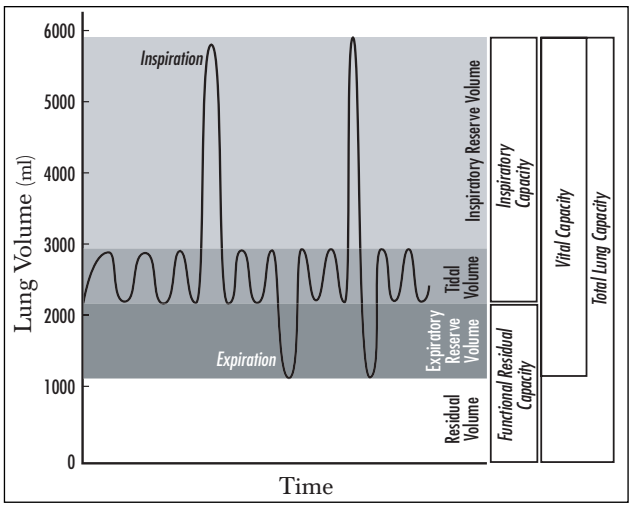


FIGURE 9–1. Illustration of respiratory excursions during: Normal breathing; Maximal inspiration; Maximal expiration

Maximal mid expiratory flow rate (MMEF): average flow rate, between 25% to 50% of FVC

Maximal voluntary ventilation (MVV): the maximum volume of air exhaled in a 12-second period in liters per second

Maximal static inspiratory pressure (PI max): static pressure measured near RV after maximal expiration

Maximal static expiratory pressure (PE max): static pressure measured near TLC after maximal inspiration

Minute volume: tidal volume × rate of breathing per minute

Other important definitions

🕮 Maximal Oxygen consumption

Expired gases during maximal exercise are collected and analyzed for oxygen content.

VO_2 max-volume of consumed O_2. Can be calculated using the Fick equation:

VO_2 max = (HR × SV) × AVO_2 difference (Note: SV=Stroke Volume; HR=Heart Rate)

- Individual VO_2 max is dependent on body weight, age (peak is reached at approximately 20 years of age), sex (values for females are approximately 70% those of males), and natural endowment (the most important)
- Training or the presence of pathological conditions can affect this potential
- Endurance exercise training increases VO_2 maximum, cardiac output, and physical work capacity of untrained healthy individuals

🕮 CLASSIFICATION OF RESPIRATORY DYSFUNCTION

Obstructive Pulmonary Disease (OPD)—Intrinsic Lung Disease

- 🕮 Characterized by increased airway resistance due to bronchospasm resulting in air trapping, low maximum midexpiratory flow rate, and normal to increased compliance
- 🕮 Impaired blood oxygenation secondary to perfusion-ventilation mismatching. Gas exchange surface of the lung is decreased as a result of air trapping. With decreased diffusion, hypoxia is present with normal or increased ventilation
- Usually eucapnic or hypocapnic, despite severe hypoxia. Hypercapnia occurs in acute respiratory failure or end-stage disease
- 🕮 Flattening of the diaphragm, with increased airway resistance, expiratory effort, respiratory muscle fatigue

Incidence: 10% to 40% of all Americans
Fifth leading cause of death in the United States
Fifty percent have limitations in activity level and 25% are limited to bed activities.

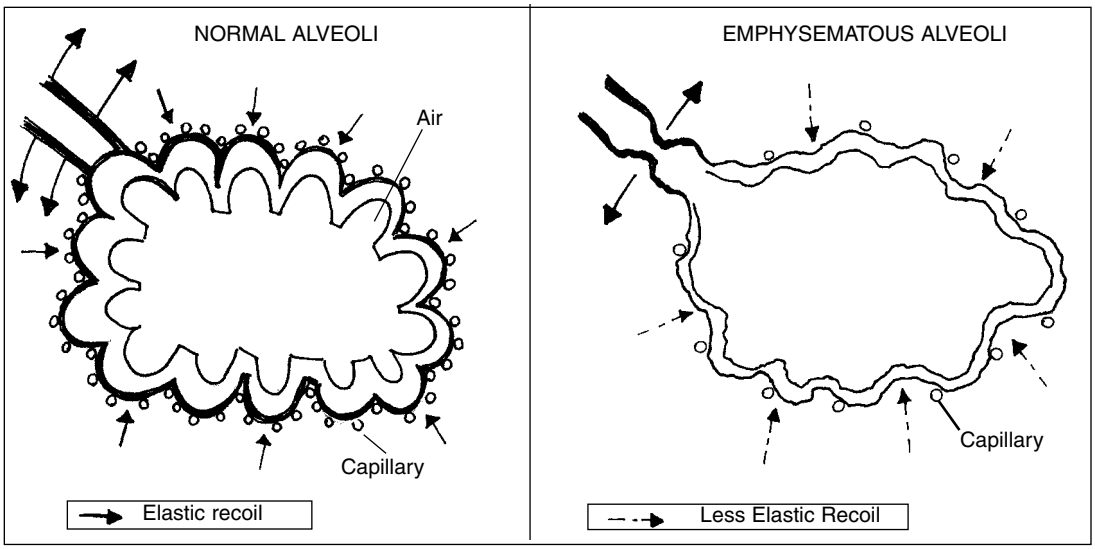
Caused by a combination of factors
- Genetic predisposition
- Respiratory infections
- Chemical inflammation (cigarette smoke, asbestos)
  Cigarette smoke is the most common cause of chronic bronchitis and emphysema.
  Causes chronic inflammation and decreased mucociliary clearance
  Smokers are more likely to die from COPD than nonsmokers (3.5 to 25 times more likely)
  Smoking cessation is linked to improvement in the following:
  – Improvement in symptoms
  – Improvement in pulmonary function
  – Decreased risk of respiratory tract infection
  – Decreased reduction in rate of loss of FEV_1, (long term)
- Allergic processes (asthma)
- Metabolic deficiencies (Alpha 1-antitrypsin deficiency)

🕮 Causes of Chronic Obstructive Pulmonary Disease (COPD)
- Chronic bronchitis
- Emphysema
- Cystic fibrosis
- Asthma

REMEMBER ALL FORMS OF COPD INVOLVE AIR TRAPPING

Chronic Bronchitis
- Chronic mucous hypersecretion and respiratory infections as a result of tracheobronchial mucous gland enlargement.
- Production of >100 ml of sputum/day for >3 mo., for at least two consecutive years.

🕮 *Emphysema (Figure 9–2)*
- Distention of air spaces distal to the terminal nonrespiratory bronchioles with destruction of alveolar walls. This is secondary to the unimpeded action of neutrophil derived elastase
- Loss of lung recoil, excessive airway collapse on exhalation, and chronic airflow obstruction
- Decreased gas exchange surface of the lung, arterial PO_2 decrease
- Increase in pulmonary vascular resistance in the presence of pulmonary tissue hypoxia, leading to severe pulmonary artery hypertension and right ventricular failure



Note:
1. Abundance of capillaries
2. Good elastic recoil
3. Maximum alveolar surface area
4. Standard alveolar gas volume for normal function

Note:
1. Fewer capillaries
2. Decreased elastic recoil
3. Decreased alveolar surface area
4. Increased alveolar gas volume

FIGURE 9–2 Normal Single Alveoli as Compared to Emphysematous Single Alveoli.

🕮 *Cystic Fibrosis (CF)*
- Generalized disease of the exocrine glands. Respiratory involvement is caused by failure to adequately remove secretions from the bronchioles, resulting in widespread bronchiolar obstruction and subsequent bronchiectasis, overinflation, and infection
- 🕮 Aerobic exercise for cystic fibrosis patients helps to increased sputum expectoration. Patients have increased ciliary beat with improved mucous transport
- Aerobic exercise also improves exercise capacity, respiratory muscle endurance, and reduces airway resistance

Asthma
- Hypertrophy of bronchial muscle, mucosal edema, and infiltration with eosinophils and mononuclear cells, which cause changes in the basement membrane. Chronic bronchitis can result from asthma
- Episodic widespread narrowing of airways, and paroxysmal expiratory dyspnea at night

The magnitude of functional impairment in COPD patients can be assessed using Pulmonary Function Tests (PFTs)
- When the predicted FEV_1 is close to 4 liters, the patient should not have a history of significant exercise impairment
- Impairment develops when FEV_1 falls below 3 liters per second
- Between 2 to 3 liters the patient may experience mild exercise limitation (able to walk significant distances, but not at high speed)
- FEV_1 between 1 to 2 liters, the patient may experience moderate degree of exercise impairment (intermittent rest periods are required to walk significant distances or to climb stairs)
- $FEV_1 < 1$ liter, severe exercise impairment (very short distance ambulation)

Restrictive Pulmonary Disease—Mechanical Dysfunction

- 🕮 Impaired lung ventilation as a result of mechanical dysfunction of the lungs or the chest wall, with respiratory muscle dysfunction. Stiffness of the chest wall or the lung tissue itself
- Hypercapnia precedes hypoxia, causing oxygenation abnormalities
- Almost all lung volumes are decreased

🕮 Causes of Restrictive Pulmonary Disease

- Chest Wall Disease (increased stiffness of chest wall)
  - Neuromuscular disease (e.g., Duchenne's muscular dystrophy)
  - Thoracic deformities (e.g., kyphoscoliosis)
  - If scoliotic angle is >90 degrees, patients have dyspnea; with >120 degrees patients present with hypoventilation and may have cor pulmonale
  - Ankylosing spondylitis (limited expansion of the chest wall)
  - Cervical spinal cord injury
- Intrinsic Lung Disease (increased stiffness of lung tissue)
  - Interstitial lung disease
  - Pleural disease
  - Surgical removal of lung tissue
    Note: Intrinsic lung disease can lead to pulmonary HTN, Right Ventricular Hypertrophy, and cor pulmonale

Examples of Chest Wall Disease

Neuromuscular Disease

- Weakness of respiratory muscles impairs the bellows activity of the chest wall, limiting ventilatory capacity and causing hypoventilation
- Respiratory muscle weakness causes impaired cough
- Examples: Duchenne's Muscular Dystrophy (DMD), Amyotrophic Lateral Sclerosis (ALS), Guillain-Barré Syndrome (GBS), Myasthenia Gravis (MG)

Duchenne's Muscular Dystrophy—sex-linked recessive

- 🕮 Patients present with several respiratory complications including:
  - Atelectasis
  - Pneumonia
  - Chronic alveolar hypoventilation (CAH) with hypoxemia
  - Ventilatory failure
- About 73% of the patients die from severe carbon dioxide retention due to CAH
- DMD patients develop progressive scoliosis, which limits expansion of the chest wall and interferes with respiration

Amyotrophic Lateral Sclerosis

- Most common form of motor neuron disease that causes respiratory failure. Respiratory failure usually develops late in the disease and is the most common cause of death
- Respiratory muscle weakness causes ventilatory limitation and impaired cough
- If symptoms begin with limb weakness the disorder may progress to respiratory failure in 2–5 years

Thoracic Deformities (i.e., Kyphoscoliosis)

- Severe Kyphoscoliosis limits expansion of chest wall, reduces lung volumes, and compromises respiratory muscle efficiency
- If scoliotic angle is > 90 degrees, patients suffer dyspnea
- If scoliotic angle is > 120 degrees, patients suffer hypoventilation and cor pulmonale

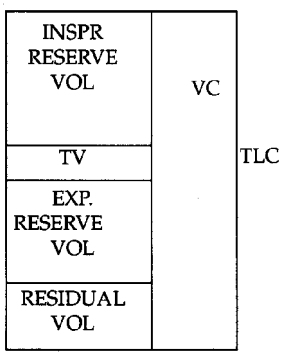
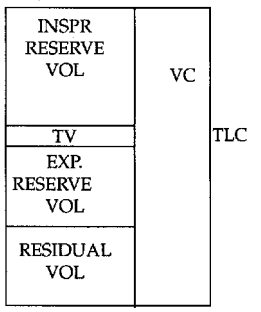
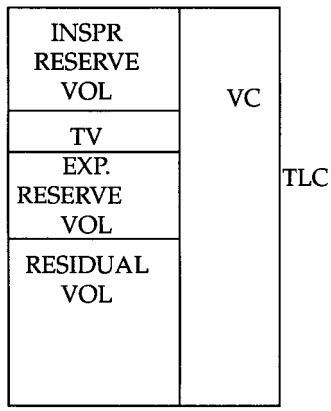
Ankylosing Spondylitis

- There is limited expansion of chest wall secondary to the ankylosing process.

Cervical Cord Injury

- Diaphragm is innervated by the phrenic nerve (at C3–C5)
- Spinal cord trauma sparing phrenic nerve innervation leaves diaphragm function intact and adequate ventilation can be sustained
- Although lower cervical and high thoracic cord lesions leave diaphragm function intact, they eliminate intercostal and abdominal muscle function, severely impairing cough mechanism
  - These patients have difficulty clearing secretions and ventilatory failure ensues
- Lesions above C3 eliminate all but accessory muscles of breath
- RV increases in C-spine injury

PULMONARY FUNCTION EVALUATION

Normal lung volumes	Restrictive lung disease	Obstructive disease (COPD)
		
🕮 **Normal changes noted with aging**	**Key point:** **All volumes are decreased**	🕮 **Key point:** **Air trapping occurs**
• Decreases in VC MVV FEV_1 PO_2 • **FEV_1 decreased at a rate of 30cc/yr** • **No changes in** TLC PCO_2 • **Increases in** RV FRC	**Increased stiffness of chest wall** Ankylosing spondylitis Cervical SCI Neuromuscular disease including: DMD, ALS, MG, GBS Kyphoscoliosis **Increased stiffness of lung** Pulmonary edema Interstitial lung disease • **Decreases in** 🕮 VC 🕮 TLC 🕮 RV FRC FVC MVV (decreases in severity) All volumes are decreased, this is distinctive for restrictive lung disease • 🕮 FEV_1 is normal Note: RV increases in C-spine injury	**Limitation in expiration before air is fully expired** Emphysema Cystic fibrosis Asthma Chronic bronchitis **Flattening of the diaphragm** Increased: Airway resistance Expiratory effort Respiratory muscle fatigue Impaired gas exchange as a result of air trapping leads to resp. muscle fatigue. • **Decreases in:** VC FEV_1 MVV FVC • FEV_1 decreases 45 to 75 cc/yr. in COPD patients • **Increases in:** 🕮 RV FRC 🕮 TLC

Key: Refer to lung volume definitions for abbreviations.
Note: MVV decreases in most pathological states and aging.

LUNG VOLUME CHANGES PRESENT IN DIFFERENT CONDITIONS

Tobacco use with normal aging

📖 The rate of decrease in FEV_1 is approximately 30cc/year

- In smokers this can increase to 2–3 times this value. Smokers with an age < 35 years can increase lung function if they quit smoking. If patient is > 35 years of age and quits smoking, the rate of decline of lung function slows to the normal rate associated with aging

Cervical spinal cord injury

Cervical spinal cord injured patients have restrictive lung disease.

📖 Pulmonary changes seen in C5 quadriplegics

- Diaphragm remains intact and the expiratory muscles are paralyzed
- Patients retain approximately 60% of their inspiratory capacity and ventilate well, but have weak cough and difficulty clearing secretions during respiratory infections
- All volumes are greatly reduced because of limited expansion of the chest wall
- Decreased TLC and VC
- Increased RV
- 📖 In patients with spinal cord injury, the abdominal contents may sag due to the greater strength of the diaphragm relative to the weakness of the abdominal wall muscles. This decreases diaphragmatic excursion and the vital capacity in the sitting position.
- 📖 The reduction in vital capacity is most severe in quadriplegics with cervical cord injury and during the acute injury period. Severity of reduction increases with higher level of injury. A study by Maloney reported that in the sitting position the use of an abdominal binder improved vital capacity. (Figure 9–3) (Maloney, 1979)
- The goal of pulmonary rehabilitation of the SCI patient is to:
  - Increase vital capacity
  - Maintain good pulmonary hygiene
  - Subjectively improve dyspnea as it relates to patient functional mobility and self-care
  - Reduce average number of hospital stays

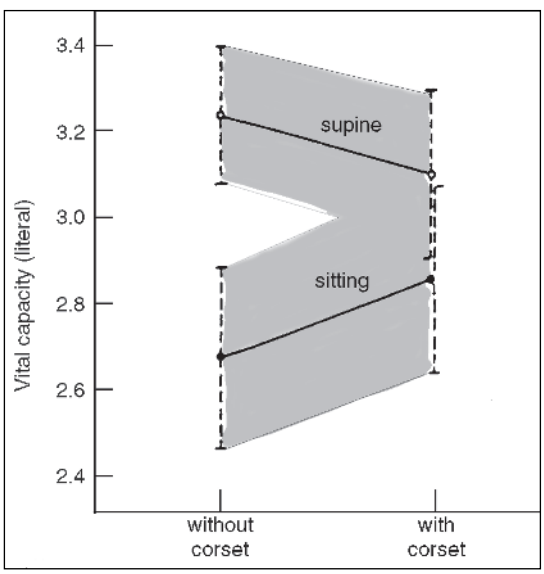


FIGURE 9–3. Comparison chart of actual vital capacities with and without wearing a corset in supine and sitting position. The chart shows the interaction of the position and the use of the corset. Note the significant difference in vital capacity in the patient without the corset in the supine vs. the seated position. The vital capacity is improved in the seated position with corset.

Duchenne's muscular dystrophy

- Vital capacity plateaus between 1,100 and 2,800 ml between 10 and 15 years of age
- Independent of chest deformity, the vital capacity is then lost at a rate of 200 to 250 ml/year. The rate of loss tapers below 400 ml

📖 No clear guidelines have been established for determining the point at which ventilatory support should be instituted in patients with Duchenne's muscular dystrophy, but various studies suggest the following:

- Dyspnea at rest
- Vital capacity, 45% predicted
- Maximal inspiratory pressure < 30% predicted
- Hypercapnia

Amyotrophic lateral sclerosis (ALS)

- Routine pulmonary function tests, including functional vital capacity, should be monitored closely in ALS
- The earliest changes noted are decreases in maximum inspiratory and expiratory muscle pressures, followed by reduced vital capacity and maximum breathing capacity
- When VC falls to 25 ml/kg of body weight, the ability to cough is impaired, increasing the risk of aspiration pneumonia
- 🕮 Functional vital capacity is the best prognostic indicator for noninvasive ventilation in patients with ALS. Patients may lose VC at a rate 1,000 ml or more per year.
- Blood gases remain normal until the patient is near respiratory arrest (Bach 1996)

REHABILITATION OF THE PATIENT WITH COPD

1. Evaluate Nutritional State

- Respiratory muscle weakness is associated with metabolic deficits
- Decreased magnesium, calcium, potassium, and hypophosphatemia are associated with respiratory muscle weakness which is reversible after replacement
- Serum albumin level correlates better with hypoxia than spirometric values. Indicates visceral protein depletion and is a good predictor of rehabilitation potential
- Impaired nutritional status is associated with increased morbidity and mortality
  - More frequent infections: Impaired cell-mediated immunity
  - Decreased macrophage action in the pulmonary alveolar region
  - Increased bacterial adherence and colonization in upper and lower airways
  - Pseudomonas species commonly colonize in patients with poor nutrition
- Poor nutritional state affects lung repair mechanisms, including surfactant synthesis
  Can lead to generalized weakness, affecting respiratory function, and finally, hypercapnic respiratory failure, and problems with weaning from mechanical ventilation

2. Optimize Pharmacologic Treatments Prior to Starting the Rehabilitation Program

- 🕮 For reversible bronchospasm
  - methylxanthines
  - Beta-2 agonists
  - Anticholinergics—e.g., Atrovent® or Ipratropium®, can be used alone or added to a regimen, including beta-2 agonists. Block smooth muscle muscarinic receptors
- Theophylline—has a bronchodilator effect, decreases diaphragm fatigue; increases cardiac output, and improves mucociliary clearance in COPD
- 🕮 Young patients with moderate asthma, who have tried B-2 agonists during exercise, may benefit from theophylline use
- Systemic steroid inhalers. Important to instruct inhaler use with the patients—>60% of COPD patients use them incorrectly
- Expectorants and mucolytics may be used for secretion management
- Increase fluid intake
- Low flow nasal supplemental O_2 can be used during therapy to reduce dyspnea and improve exercise performance, especially in patients with documented Coronary Artery Disease (CAD)

- 🕮 O_2 is recommended for patients who desaturate during exercise. The most accepted guideline for O_2 use during exercise is if the patient exhibits an exercise induced SaO_2 below 90%
- Inspiratory phase or pulsed oxygen therapy, especially if provided transtracheally, decreases mucosal drying and discomfort. O_2 delivery is of 0.25 to 0.4 L/ min. compared to 2–4 L/min. via face mask or nasal cannula
- Supplemental O_2 use is also recommended for patients with a continuous PO_2 of 55 to 60 mm Hg
  🕮 Benefits of home oxygen use include:
  1. Reduction in polycythemia
  2. Improvement in pulmonary hypertension
  3. Reduction of the perceived effort during exercise
  4. Prolongation of life expectancy
  5. Improvement in cognitive function
  6. Reduction in hospital needs
- Cessation of smoking should be emphasized

3. Train in Controlled Breathing Techniques

- COPD patients exhibit an altered pattern of respiratory muscle use. The rib cage inspiratory muscles generate more pressure than the diaphragm. Expiratory muscles are also involved
- 🕮 Controlled breathing techniques are used to reduce dyspnea, reduce the work of breathing, improve respiratory muscle function and pulmonary function parameters. Different types may be used in patients with obstructive pulmonary disease and restrictive disease

Techniques to Improve Pulmonary Function Parameters

Diaphragmatic breathing

- Used to reverse altered pattern of respiratory muscle recruitment in COPD patients.
- Patient uses the diaphragm, relaxes abdominal muscles during inspiration:
  Lying down, or at 15% to 25% head-down position, the patient places one hand over the thorax below the clavicle to stabilize the chest wall, and the other over the abdomen. The patient takes a deep breath, and expands the abdomen using the diaphragm. Feedback of abdominal and rib cage movement is obtained through hand placement as described previously
  🕮 ***Benefits:*** increased tidal volume, decreased functional residual capacity, and increase in maximum oxygen uptake.

Segmental breathing

- Obstructions, such as tumors and mucous plugs, should be cleared prior to practicing this technique
- The patient is asked to inspire while the clinician applies pressure to the thoracic cage to resist respiratory excursion in a segment of the lung. As the clinician feels the local expansion, the hand resistance is decreased to allow inhalation. This facilitates the expansion of adjacent regions of the thoracic cavity that may have decreased ventilation

Techniques to Reduce Dyspnea and the Work of Breathing

Pursed-lip breathing

Patient inhales through the nose for a few seconds with the mouth closed, then exhales slowly for 4–6 seconds through pursed lips. By forming a wide, thin slit with the lips, the patient creates an obstruction to exhalation, slowing the velocity of exhalation and increasing mouth pressure. Expiration lasts 2–3 times as long as inspiration.

🕮 **Benefits:** Prevents air trapping due to small airway collapse during exhalation and promotes greater gas exchange in the alveoli. Increases tidal volume, reduces dyspnea and work of breathing in COPD patients. When added to diaphragmatic breathing, reduces the respiratory rate and can improve blood ABGs. (Bach, 1996)

4. Maintain an Adequate Airway Secretion Management Program

Airway clearance techniques (Controlled cough, Huffing)

Controlled cough

The patient assumes an upright sitting position, inhales deeply, holds the breath for several seconds, contracts the abdominal muscles ("bears down" increasing intrathoracic pressure), then opens the glottis and rapidly and forcefully exhales while contracting the abdominal muscles and leaning slightly forward.

This is repeated two or three times and followed by normal breaths for several minutes before attempting controlled cough.

Coughing generates high expulsive forces promoting secretion retention and may exacerbate air trapping; also leads to fatigue if the cough is weak.

Huffing

An alternative is huffing—following a deep inhalation, the patient attempts short, frequent exhalations by contracting the abdominal muscles and saying "ha, ha, ha".

The glottis remains open during huffing, and does not increase intrathoracic pressure, therefore, in COPD patients where airways can collapse. This is a more efficient means of secretion removal.

Secretion Mobilization Techniques (Postural Drainage, Percussion, Vibration)

Indications: Sputum production >30 ml/day
Aspiration
Atelectasis
Moderate sputum production in debilitated patients that are unable to raise their own secretions

Postural Drainage

Use gravity-assisted positioning to improve the flow of mucous secretions out of the airways. The affected lung segment is placed uppermost to increase oxygenation and drainage.

Best done after awakening in the morning (secretions accumulate at night) and one to two hours after meals to avoid gastroesophageal reflux.

🕮 *Positions for postural drainage (Figure 9–4)*

A common position is the Trendelenburg or head-down posture, which can be done with the patient supine or prone, and different postural variations such as side lying or trunk bending.

To drain the upper lobes:
Patient is positioned sitting up
Exceptions:
- Right anterior segment—Patient supine
- Lingular—Patient in lateral decubital Trendelenburg
- Both posterior segments—Prone

To drain the right middle lobe and lower lobes:
Patient is positioned in the lateral decubital Trendelenburg

Exceptions:
- Superior segment of the lower lobe—Patient prone with buttocks elevated
- Posterior lower segment—Patient in prone Trendelenburg position with buttocks elevated
- Anterior segment—supine Trendelenburg

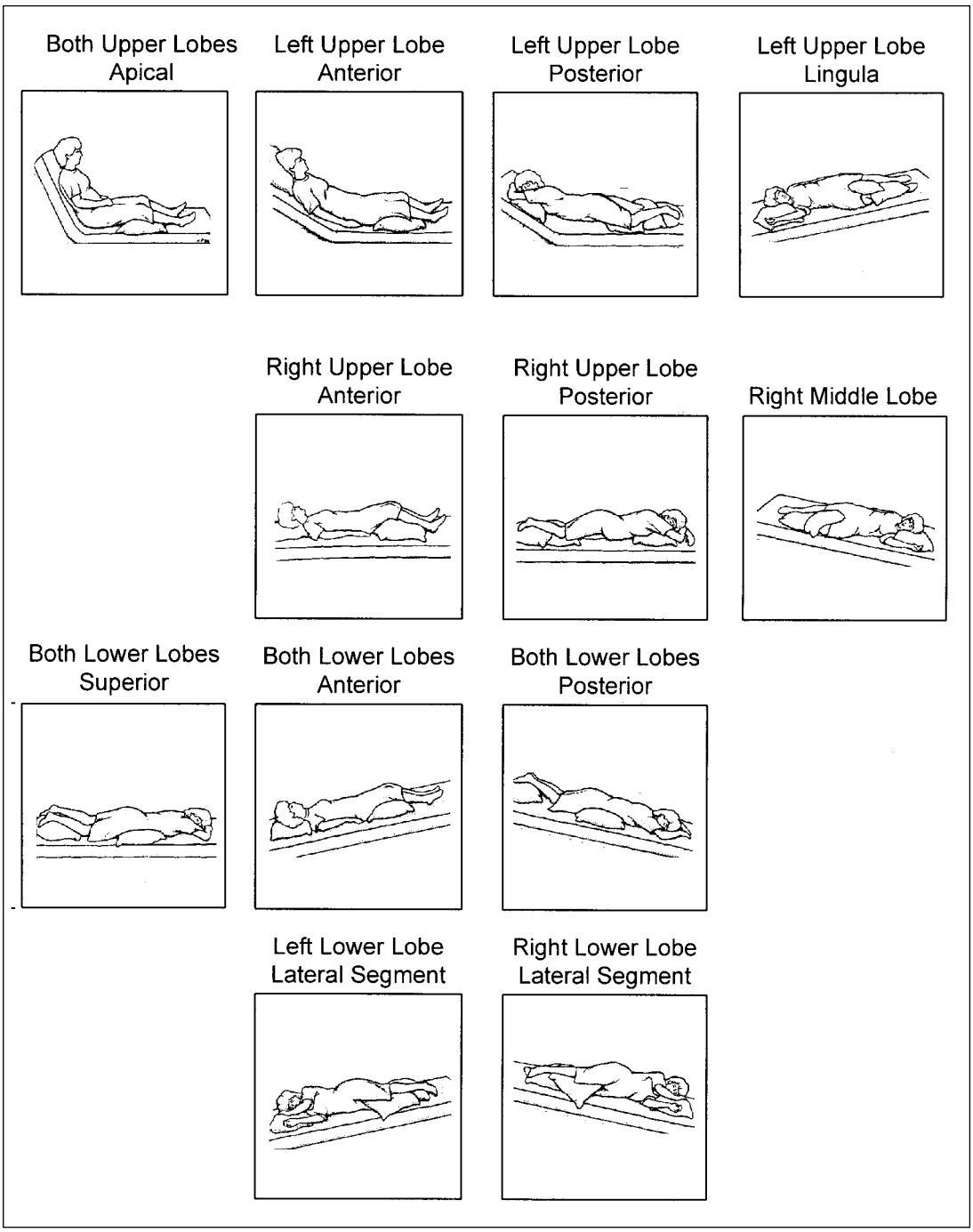


FIGURE 9–4. Postural Drainage Positions.

Precautions for postural drainage:

Head-down—Trendelenburg

Head-down tilt can range from 10° to 45°. COPD patients can tolerate up to 25° tilt.

Avoid in: Pulmonary edema
CHF
HTN
Dyspnea
Abdominal problems—hiatal hernia, obesity, recent food ingestion, abdominal distention.

Side-lying position

Contraindications: Axillofemoral bypass graft
Musculoskeletal pain—e.g., rib fractures

🕮 *Postural Changes*

Postural changes not only help with secretion mobilization but affect the work of breathing by changing the mechanical load on the respiratory muscles and the oxygen supply and consumption in these areas

1. Mechanical load—Pressure changes related to position

- Upright position—Abdominal contents remain in low position due to gravity; diaphragm can compress them easily
- Supine position—Redistributes abdominal contents. Diaphragm is in a slightly longer resting position further up into the thorax
- Head-down Trendelenburg—Diaphragm at its longer resting position, displaced by the weight of the abdominal contents into the thorax

With progression from the sitting to the Trendelenburg position, the diaphragmatic work of breathing is increased (the abdominal content load increases). The diaphragm will accommodate to the increase in load by increasing its contraction.

In obesity, the external load of the abdominal muscles may be greater than the muscle's capacity of contraction.

In neuromuscular disease, the muscles may not be able to generate tension against the abdominal content load, requiring changes in posture to assist in breathing. This is also valid for COPD patients where postural changes can affect the diaphragmatic mechanical response.

🕮 The weight of the pulmonary tissue also contributes to overall pressure on the most dependent alveoli. The dependent alveoli expand in size when changing from sitting to supine position, increasing ventilation at the base of the lung.

2. Blood flow—gravity dependent

Maximum flow is greatest at the most gravity dependent portions of the lung.

- Upright sitting—Ventilation/Perfusion (V/Q) mismatch, most effective at the middle lung fields

  Blood flow is more at the lower fields, while gas distribution is initially distributed through the apices. With inspiration, the fall in pressure will draw the greatest gas volume to the more dependent areas of the lung.
- In some patients changing from supine to prone positioning displaces the weight of the abdominal contents, reversing blood flow distribution to the anterior segments
  - 🕮 The difference in blood flow distribution is based on the pressure affecting the capillaries: (Figure 9-5)
  - The pressure of the surrounding tissues can influence the resistance to blood flow through the capillaries
  - Blood flow depends on pulmonary artery pressure, alveolar pressure, and pulmonary venous pressure

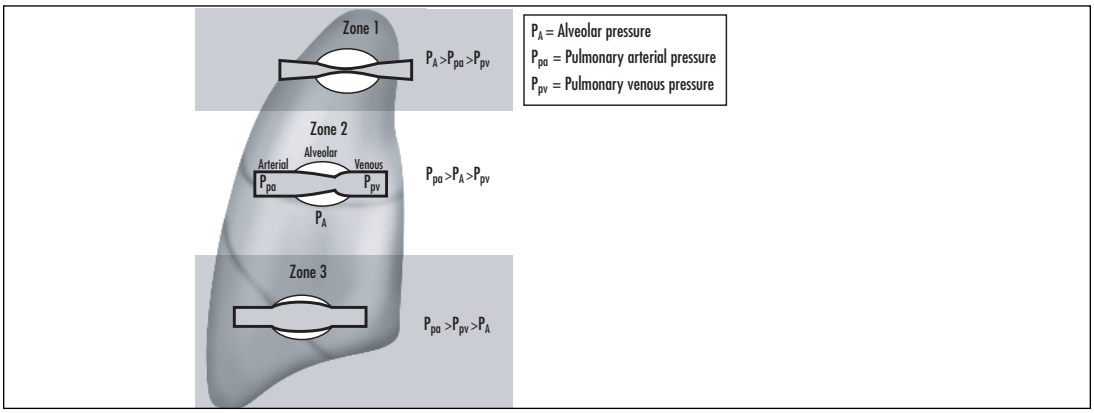


FIGURE 9–5. 3 Zone Model of the Lung: The difference in blood flow distribution is based on the pressure affecting the capillaries.

Zone 1: Alveolar Pressure (PA) exceeds Pulmonary Artery Pressure (Ppa), and no flow occurs because the vessels are collapsed.

Zone 2: Arterial Pressure (Ppa) exceeds alveolar pressure but Alveolar Pressure (PA) exceeds Pulmonary Venous Pressure (Ppv). The arterial-alveolar pressure difference (Ppa–PA) determines the flow in Zone 2. This steadily increases down the zone.

Zone 3: Pulmonary Venous Pressure (Ppv) exceeds alveolar pressure and flow is determined by the Arterial Venous Pressure (Ppa) difference (Ppa–Ppv) which is constant down this pulmonary zone. Note the pressure across the vessel walls increases down the zone so their caliber increases. As the caliber of the vessel wall increases, so does the flow.

- The perfusion of the lung is dependent on posture.
- The perfusion of the 3-zone model of the lung in the upright position is described below. (Figure 9–6A)
  Zone 1: Ventilation occurs in excess of perfusion
  Zone 2: Perfusion and ventilation are fairly equal
  Zone 3: Is the most gravity dependent region of the lung where

Pulmonary Artery Pressure > Pulmonary Venous Pressure, which is > Alveolar Pressure

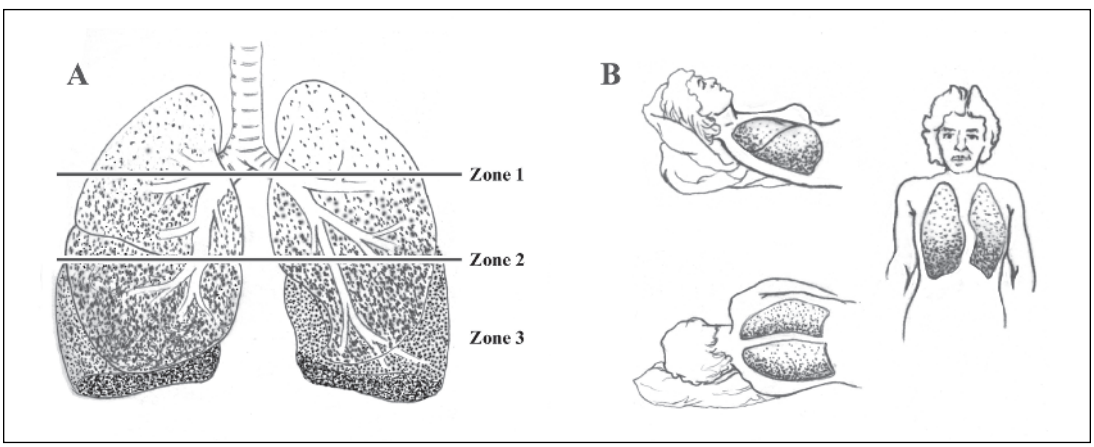


FIGURE 9–6. **A:** Perfusion of the lung is dependent on posture. This diagram shows the perfusion of the lung in the upright position. **B:** Perfusion of the lung is effected on positioning of the patient. The gravity-dependent segments have the greatest amount of perfusion.

- 🕮 When changing from a sitting to supine position, venous pressure increases in relation to the arterial pressure in dependent areas of the lung
- Blood flow is governed by the pulmonary arterial to venous difference
- When supine, the apical blood flow increases, but the bases remain virtually unchanged. There is an almost uniform blood flow throughout the lung. However, posterior segment flow will exceed anterior segment perfusion in this position.
- The normal ratio of ventilation/perfusion is 0.8. Areas of low ratios (perfusion > ventilation) act as a shunt. Areas of high ratios act as dead space.

Percussion
Mechanical percussor or a cupped hand can be used to rhythmically strike the thoracic cage during the entire respiratory cycle to loosen mucus within the lungs.
Delivered at a frequency of 5 Hz for 1 to 5 minutes or longer over the chest area desired to be drained.
Used on patients who are unable to mobilize and expectorate excess secretions, or to help expand areas of atelectasis.

Precautions:
Coagulation disorders
Anticoagulation therapy
Platelet count below 50,000
Fractured ribs
Flail chest
Severe osteoporosis

Contraindications:
Cardiovascular instability or failure
Aortic aneurysm
Increased intracranial pressure
Increased intraocular pressure
Cannot do percussion over a tumor

Vibration
Rapid shaking back and forth, (not downward) on the thorax over a segment of the lung, causing mucus to move toward the trachea. Applied to the thorax or airway to facilitate secretion elimination.
Can be applied manually or through the use of a mechanical vibrator.

Mechanically:
Vibrator can be used at frequencies ranging from 10–15 Hz up to 170 Hz
Most animal studies favor the 10–15 Hz frequency range

- Uses very little or no pressure on the thorax, and constitutes an alternative in cases where percussion is contraindicated
- The effects of mechanical chest percussion and vibration are frequency dependent
- Side effects of percussion and vibration can include increased obstruction to airflow in COPD patients

Preoperative and Postoperative Chest Therapy Program
Airway clearance and secretion mobilization techniques can be applied prior to surgery, and after the procedure
🕮 A preoperative and postoperative chest therapy program has the following advantages:
- Decreases the incidence of pneumonia

- Reduces the probability of developing postoperative atelectasis following thoracic and abdominal surgery

Pre-operative Program: The patient is taught standard postoperative treatment.

Deep breathing—Taught with the patient in the semi-Fowler position, in which the abdominal muscles are on slack. This allows greater diaphragmatic excursion. Most important modality of postoperative pulmonary hygiene.

Rolling—Allows patient mobility and minimizes trunk movement

Coughing—Decreased cough effectiveness can be a result of anesthesia
Two-stage cough, preceded by a deep diaphragmatic breath. First cough raises the secretions, second cough facilitates expectoration. May use splinting techniques for coughing, splinting the surgical incision with the use of a pillow or hands.

Huffing
Incentive spirometry—Provides the patient with visual feedback of the air volume inspired during a deep breath. Patients practice deep inspiration every hour in addition to their chest physical therapy sessions.

Post-operative Treatment
Most therapy programs start one day postoperatively. Diaphragmatic and segmental breathing are used to assist the ventilator.
Breathing exercises are provided.
Secretion management techniques include postural drainage, vibration and percussion.
If the patient underwent abdominal surgery, one hand is placed between the incision site and the area to be percussed to decrease discomfort during the treatment. A pillow over the incision may also be used.
Vibration is preferred post operatively because it is less traumatic.
These treatments are contraindicated in patients with cardiac or hemodynamic instability or in cases of pneumothorax.

5. Provide Therapeutic Exercises

Used to improve respiratory muscle endurance, strength, and efficiency

Inspiratory resistive loading
- Uses an inspiratory muscle trainer. The patient inhales through its inspiratory orifices, which progressively decrease in size. Exhalation is performed without resistance
- Treatment is provided 1 to 2 times per day for approximately 15 to 30 minutes, with a rate of 10 to 20 breaths per minute. If the patient is able to tolerate 30-minute sessions, the intensity is increased by varying the orifice size. To increase endurance and orifice size that allows a longer exercise duration is chosen

Threshold inspiratory muscle training
A threshold loading device allows inspiration only after a predetermined mouth pressure is reached. Produces inspiratory resistance without relying on inspiratory flow rates. Benefits include increased ventilatory strength and endurance.
- Inspiratory muscle training has been proven beneficial in patients with cystic fibrosis, where FVC, TLC, and inspiratory muscle strength have been improved
- Inspiratory muscle training has appeared to prevent the weakness associated with steroid use in patients with this type of medication, as documented in one controlled study

– In patients with asthma, a reduction in asthma symptoms has been noted in addition to the documented improvement in the inspiratory muscle strength and endurance. A reduction in hospitalizations and emergency room visits, increase in school and work attendance, and reduction in medication use has also been found.

6. Instruct In Reconditioning Exercises

This type of exercise allows the patient to increase the ability to perform ADLs. The patient is engaged in a progressive program for which he or she is made responsible.

– Activities may include: aerobic conditioning (bicycle, pool exercise program, walking, stair climbing, calisthenics), ROM exercises (coordinated with diaphragmatic breathing) and upper extremity strengthening exercises
– A daily 12-minute walk with a record of time spent and distance achieved; and 15 minutes a day of inspiratory training is also advised. The 12-minute walk can be used to estimate exercise tolerance
– Pulse parameters include: increase of at least 20% to 30% during the activity with a return to baseline within 5 to 10 minutes after exercise
– The program is reevaluated weekly for 10 to 12 weeks, and modifications are made along with patient education
– Upper extremity exercise reduces the metabolic demand and increased ventilation associated with arm elevation, and dyspnea
– Unsupported upper extremity activities produced the most benefits, including decreased O_2 consumption. These type of activities include self-care, lifting, reaching, carrying, and athletic activities
– All exercises should be performed to tolerance (symptom limited, subjective dyspnea)
– Should hold exercise for a HR >120 beats/minute
– Hold exercise if the patient has premature beats > 6/minute
– Hold exercise for oxygen saturation less than 92%. If the patient desaturates during exercise (<90%) may use supplemental O_2 to enhance exercise performance and protect patients with CAD from dysrhythmia
  🕮 Aerobic exercise in patients with cystic fibrosis may include:
  – Exercises involving the trunk muscles such as sit-ups
  – Swimming
  – Jogging
– 🕮 Patients with CF that participate in a structured running program show significant improvements in exercise capacity, respiratory muscle endurance, and a reduction in airway resistance. In addition, studies in children with CF have found increased sputum expectoration and an improvement in lung function after several weeks of strenuous regular aerobic exercise.

7. Muscle Rest Periods Should Be Added to the Exercise Program

Monitor hypercapnia as an indicator for the need of a rest period.
Ventilatory assistance provides relief to tired respiratory muscles decreasing their energy expenditure. Diaphragm rest can be achieved by assisting ventilation noninvasively with the use of body ventilators, mouthpiece, or nasal intermittent positive pressure ventilation (IPPV) or tracheostomy IPPV.
Although assisting ventilation can exacerbate air trapping in COPD patients, the benefits of resting respiratory muscles and decreasing oxygen consumption may outweigh this in importance

Two groups of COPD patients may benefit from ventilatory assistance

1. Medically and psychologically stable patients who require assistance around the clock, usually by tracheostomy route
2. Patients with need of nocturnal assistance only
   The nocturnal use of ventilators supports weak respiratory muscles
   Potential benefits include:
   – increased vital capacity, respiratory muscle strength and endurance, and decreased need for hospitalizations

Ventilatory assistance for COPD patients includes Positive Pressure Airway Ventilators and Negative Pressure Body Ventilators

Positive Pressure Airway Ventilation can be intermittent (IPPV), continuous (CPAP), or bilevel (BiPAP).

- Intermittent Positive Pressure Ventilation (IPPV) is the most common method of noninvasive support
  For mouthpiece IPPV, a mouthpiece is set up near the mouth, where the patient can easily grab it up to 6 to 8 times a minute for full ventilatory support. It is an ideal inspiratory muscle aid for day time use.
  For nocturnal use, nasal IPPV with CPAP mask (adequate seal is a problem) or mouthpiece IPPV with lip seal retention (seal is adequate, but patient cannot talk).
- 🕮 Continuous Positive Airway Pressure ventilation (CPAP) may be used to help maintain patent airways in patients with sleep disordered breathing (obstructive sleep apnea). It produces splinting of the pharyngeal airway with positive pressure delivered through a nose mask. This method prevents desaturation.
- Bilevel positive airway pressure (BiPAP) permits independent adjustment of inspiratory (IPAP) and expiratory positive airway pressure (EPAP)

Negative Pressure Body Ventilators (NPBV) used during the day or night have provided the following benefits:

- Improved respiratory endurance with decrease in dyspnea
- Improved in quality of life, 12-minute walking distance
- Improved transdiaphragmatic pressure, and maximum inspiratory and expiratory pressures

NPBV ventilators assist respiratory muscles by creating atmospheric pressure around the thorax and abdomen

NPBV are also an alternative to intubation and tracheostomy for patients with acute respiratory failure (Bach 1998)

REHABILITATION OF THE PATIENT WITH RESTRICTIVE LUNG DISEASE

Respiratory complications are the most common causes of death in advanced restrictive lung disease. The major cause of acute respiratory failure for these patients is impaired secretion clearance. Rehabilitation of the patient with restrictive lung disease is based on prevention of complications and assistance with secretion management.

1. Patient Education

- Prevents development of pneumonia, respiratory failure, and subsequent intubation and mechanical ventilation
- Importance of vaccinations should be stressed:
  Influenza, pneumococcal, and the possible use of antiviral agents
- Avoid crowded areas or exposure to respiratory tract pathogens
- Avoid sedatives at night and the risk of possible aspiration

- Avoid oxygen therapy. Central ventilatory drive can be suppressed, exacerbation of carbon dioxide can occur, and the risk of respiratory failure can be increased
  Studies indicate that O_2 therapy can prolong hypopneas and apneas by 33% during rapid eye movement (REM) and by 19% otherwise, even in patients with mild neuromuscular disease
- Avoid obesity and heavy meals
- Develop goals and start planning for the future

2. Keep A Good Nutritional State

- Respiratory muscle insufficiency can be exacerbated by hypokalemia
- Patients with Duchenne muscular dystrophy have decreased total body potassium, and commonly develop hypokalemia during acute illnesses

3. Instruct In Controlled Breathing Techniques

Glossopharyngeal breathing

- This is a noninvasive method to support ventilation, and it can be used in the event of ventilator equipment failure
- The patient takes a deep breath, and uses the pistoning action of the tongue and pharyngeal muscles to project air boluses into the lungs. Rhythmic opening and closing of the vocal cords occurs with each air bolus
- Each breath usually consists of 6 to 9 air boluses (or up to 65), with each bolus consisting of 30 to 150 ml of air (usually 60 to 200 ml.)
- Requires intact oropharyngeal muscle strength, and the patient should not be tracheostomized

🕮 Other uses of glossopharyngeal breathing

- Enables the patient to breathe without mechanical ventilation (up to 4 or more hours if the lungs are normal; if lungs are affected may only tolerate minutes). This time off the ventilator can be used to transfer to different types of aids
- Improves the volume of the voice and the rhythm of speech, allowing the patient to shout
- Helps prevent micro-atelectasis
- Allows the patient to take deeper breaths for more effective cough
- Improves or maintains pulmonary compliance

Use deep breathing and insufflations

- A program of air stacking hyperinflations 2 to 4 times a day with progressively increasing volumes helps prevent atelectasis and can benefit VC
- Regular maximal insufflations can be provided with manual resuscitators, portable ventilators, and mechanical insufflators-exsufflators. A mouthpiece may be used, or a nosepiece may be provided for larger volumes and when patients have weak oral muscles

4. Use Adequate Secretion-Management Techniques

Manually assisted cough

- The clinician's or the assisting person's heel of the hand or arm is placed at various sites along the anterior chest or abdomen to provide pressure, and is coordinated with the patient's coughing or expiratory effort
- Location of the areas of pressure:
  - Heimlich-type or abdominal thrust assist—Patient in the side-lying position, pressure is applied at the navel while pushing up the diaphragm
  - Costophrenic assist—Patient in any position, pressure applied to the costophrenic angles
  - Anterior chest compression assist—Patient lying on the side or the three-quarter supine position, pressure applied to the upper and lower anterior chest

– Counter rotation assist—Pressure is applied to the pelvis or shoulder during inspiration followed by reversing the pressure direction to compress the thorax in all planes to facilitate expulsion

Suctioning
– Should be done in conjunction with other secretion clearing techniques, or when other techniques fail to remove secretions appropriately
– May lead to complications such as: airway membrane irritation, airway edema and wheezing, hypoxemia, bradycardia or tachycardia, hyper- and hypotension, increased intracranial pressure
– ONLY suction as you withdraw the catheter

Chest percussion, postural drainage may also be used.

Mechanical insufflator-exsufflator
– Most effective method of mechanical assistance for secretion clearance in paralyzed patients
– A deep inspiration (positive-pressure insufflation) is provided via a mask or through the tracheal tube, followed by rapid controlled suction (negative pressure exsufflation)
– Insufflation and exsufflation can be independently adjusted
– A desired decrease in pressure from insufflation to exsufflation is approximately 80 cm H_2O. This may be sustained for 2 to 3 seconds. The duration of exsufflation is longer than with other methods of assistance
– The decrease in pressure creates flows of approximately 7 to 11 L/second, helping to bring secretions to the upper airways where those can be suctioned
– It can be used in patients with scoliosis, dysphagia , impaired glottis function, and severe upper respiratory tract infections
– Allows continued ventilatory support without tracheostomy, and improves pulmonary volumes and SaO_2

5. Use Noninvasive Ventilation

Mechanically assisted ventilation provides respiratory muscle rest, decreasing the energy expenditure of the respiratory muscles.
Body ventilation—includes positive, negative/positive, and negative pressure ventilation

Positive pressure body ventilators
Provide positive pressure on the abdomen to assist diaphragmatic cephalad movement, promoting expiration. Passive inspiration occurs after removing the abdominal pressure.

• 🕮 **Intermittent abdominal pressure ventilator (IAPV)**
Examples: Pneumobelt, Exsufflation belt.
– Abdominal corset containing a battery operated rubber air sac. It helps to create forced expiration by moving the diaphragm cephalad. When deflated, the diaphragm and the abdominal contents fall to resting position, resulting in passive inspiration
– Worn from the xiphoid to above the pelvic arch. Cycles are 40% inspiration and 60% expiration. Approximately 250 to 1,200 ml of tidal volume can be provided
– Depends on gravity to assist inspiration, and is only effective when the patient is in the sitting position. A trunk angle of 75° from the horizontal is optimal but may be used with 45° in some cases
– This is the most useful mode of ventilation for wheelchair-bound patients with less than 1 hour of ventilator-free time during the day. Benefits also include liberating the mouth and hands for other activities
– Contraindicated in severe scoliosis and severe obesity. The patient should have a mobile abdomen

- Not useful in patients with decreased pulmonary compliance or increased airway resistance
- Most beneficial when used during the day in addition to nocturnal noninvasive IPPV. Inspiration may be supplemented by the use of available inspiratory muscles and or glossopharyngeal breathing

Negative and positive pressure body ventilator

🕮 *Rocking bed*

Rocks the patient along a vertical axis (15 to 30 degrees from the horizontal) utilizing the force of gravity to assist ventilation.

- When the head of the bed is up, inspiration is assisted by using gravity to pull the diaphragm down. This creates a negative pressure
- With the head down, exhalation assist is obtained. Cephalad movement of the abdominal contents pushes the diaphragm up with production of positive pressure
- It is used in patients with diaphragm paralysis with some accessory muscle function
- Benefits: prevents venous stasis, improves clearance of bronchial secretions, weight shifting prevents development of pressure ulcers, benefits bowel motility. It is easy to apply
- Disadvantages: heavy (not portable); not effective in patients with poor lung or chest wall compliance or in those with increased airway resistance

External oscillation ventilator (Hayek oscillator)

- Flexible chest enclosure (cuirass) with external oscillating ventilator
- Pressure change is developed between the cuirass and the chest wall. Negative pressure helps chest wall expansion and inspiration. Positive pressure causes chest compression and aides expiration
- Inspiratory pressure is always negative, but the expiratory pressure can be adjusted to positive, zero or subatmospheric, and negative
- By increasing the number of oscillations per minute it may be used for secretion clearance
- Patients with decreased lung compliance may use this type of assistance

Negative pressure ventilators

- Create intermittent extrathoracic pressure over the chest wall and abdomen, helping inspiration
- Main use is at night
- Provides rest to fatigued respiratory muscles
- Cor pulmonale may be prevented
- The patient may be able to function during the day without respiratory assistance
- Contraindicated in upper airway obstruction cases, where it may increase the frequency and severity of airway collapse and obstruction during the night. This may lead to obstructive apnea and desaturation
- Not useful in children < 3 years old due to recurrent pneumonias and atelectasis
- Not useful in patients with excessive airway secretions

Tank Ventilators (Emerson iron lung, LifeCare Porta-lung)

- Patient's entire body is enclosed in a chamber that produces intermittent subatmospheric pressure (Iron lung) or has a separate negative pressure generator (Porta-lung).
- Uses: Management of acute respiratory failure patients
  Ventilatory support in patients with decreased pulmonary compliance, significant scoliosis, and severe infections

Wrap Ventilators (Poncho, Pneumosuit)

- Plastic grid that covers abdomen and thorax. The wrap is sealed around the patient's wrists, neck and abdomen, or legs. A negative pressure ventilator creates subatmospheric pressure under the grid and wrap

- Provides greater volumes
- Only used with nocturnal assisted ventilation

Uses: In patients with scoliosis or with sensory deficits
Disadvantages: Difficult to don, decreased access to the body by the medical personnel; difficult to turn the patient

Cuirass or Chest Shell Ventilators

- Firm shell that covers the chest and abdomen attached to a negative pressure ventilator that generates a sub-atmospheric pressure under the shell
- It is the only Negative Pressure Body Ventilator (NPBV) that can be used during the day for ventilatory support in the seated position

Advantages: The patient can get on and off without assistance

Disadvantages: In insensate patients can cause pressure ulcers around the area anterior to the axilla

Not effective in: Patients with complete respiratory paralysis
Impairment of pulmonary compliance
Patients with apnea
Patients with intrinsic lung disease
Severe back deformity
Morbid obesity

MANAGEMENT OF SLEEP DISORDERED BREATHING

- Weight reduction can improve obstructive sleep apnea for obese patients
- Use of independently varying inspiratory positive airway pressure and expiratory positive airway pressure ventilators is very effective in patients with hypercapnia. The greater the difference between Inspiratory Positive Airway Pressure (IPAP) and Expiratory Positive Airway Pressure (EPAP), the greater the inspiratory muscle assistance
- To allow for an adequate fit, custom molded nasal interfaces may be provided
- Portable volume ventilators may be used in morbidly obese patients or patients who require high peak ventilators pressures
- An orthodontic splint that brings the mandible and tongue forward is helpful to maintain the hypopharynx open, as a long-term resource

INVASIVE VENTILATORY SUPPORT

Invasive ventilation is used when noninvasive methods fail or are inadequate
Tracheal intubation or tracheostomy is indicated when the ABGs show $PaO_2 < 55$ mm Hg, or $PCO_2 > 50$ mm Hg.

COPD and restrictive lung disease patients may need intubation for other reasons:

- Noninvasive mechanical ventilator does not deliver O_2 adequately due to poor access to oral or nasal routes, i.e., orthopedic conditions (osteogenesis imperfecta, inadequate bite or mouthpiece entry), presence of NGT, or upper airway obstruction
- Severe intrinsic pulmonary disease requiring high Frequency of Inspired Oxygen (FiO_2)
- Inadequate oropharyngeal muscle strength
- Uncontrolled seizures or substance abuse
- Assisted peak cough flow < 160 L/minute
- When mechanical exsufflator is not available or contraindicated
- Unreliable access to assisted coughing
- Depressed cognitive status

Tracheal intubation with tracheostomy tube

The choice of tracheostomy tube depends upon the patient and the duration of use

Types of tracheostomy tubes

Metal (e.g. Jackson, Holinger)
- Cuffless, reusable tubes made of stainless steel or silver
- Cause less local irritation, and tissue reaction as compared to plastic
- May be left in place longer
- Help to keep the tracheostomy stoma open until the tracheostomy is not needed, in patients who breathe spontaneously

Plastic (e.g., Bivona, Shiley, Portex)
- Disposable, made of PVC, nylon, silicone, and Teflon
- Available single or double cannulated, with/without cuff

Cuff inflated versus uncuffed

Cuff-inflated Tracheostomy Tubes
- Provide a good air seal, protects lower airways from aspiration, and prevents air leaking through the upper airway. Creates the least positive pressure against the tracheal wall.
- Patients cannot speak with cuff-inflated tracheostomy tube.
- Two types: High pressure/low volume
  - Low pressure/high volume-conform more to the shape of the trachea and inflate more uniformly

Uncuffed Tracheal Tubes
- Some patients may be able to talk while on mechanical ventilation
- Should not be used in patients at risk for aspiration because it provides a loose fit
- Used after tracheostomy, when a looser fit of the tube on the stoma is needed, or to prevent subcutaneous emphysema
- Used in patients with increased secretions
- Should not be used in patients known to aspirate

Fenestrated versus nonfenestrated tubes

Fenestrated
🕮 This tracheostomy tube is good for patients who are able speak and require only intermittent ventilatory assistance.
- A continuous inner cannula can be used with an outer fenestrated cannula. The fenestrations should lie within the lumen of the trachea, and should not touch the tracheal wall (may develop granulation tissue around the holes and become clogged with secretions)
- The inner cannula can be attached to a positive pressure ventilator
- When the inner cannula is out and the tube is plugged, the patient can breath through the fenestrations and is able to phonate. This is possible because the air is directed though the upper respiratory tract

Nonfenestrated
- Used in patients who require continuous mechanical ventilation, or are unable to protect the airway during swallowing
- 🕮 If the patient wants to talk, a one-way talking valve may be used on the tracheostomy tube. These devices open on inhalation and close during exhalation to produce phonation

🕮 Talking tubes (TT) versus speaking valves

Speaking Tracheostomy Tubes (e.g., Portex "Talk" tube, Bivona Fome-cuff with side-port airway connector, Communi-trach)

- Used in alert and motivated patients, who require an inflated cuff for ventilation and who have intact vocal cords and the ability to mouth words
- Airflow is through the glottis, supporting vocalization with airflow over the vocal cords while maintaining a closed system for ventilation
- Talking trachs supply pressurized gas mixtures through a cannula that travels through the wall of the talking tube, then enters the trachea through small holes above the inflated tube cuff so the patient can use the larynx to speak while the cuff is inflated (thus leaving mechanical ventilation undisturbed)
- The quality of speech is altered (e.g., lower pitch, coarser). Patients need to speak short sentences (because constant flow through the vocal cords can cause the voice to fade away)
- The patient requires some manual dexterity and minimal strength to occlude the external port

One-way speaking valves (e.g., Passy-Muir speaking valve, Olympic Trach-Talk)

- Passy-Muir valve is the only valve that has a biased, closed position; opens only on inspiration
- All the other valves are open at all times until they are actively closed during expiration (when enough force is placed)
- The air is directed into the trachea and up through the vocal cords, creating speech as air passes through the oral and nasal chambers
- Requires less work—opening and closing the valve is not needed
- Do not use the speaking valves with COPD patients because the lung has lost elasticity and the patient cannot force air out due to lack of lung compliance

TABLE 9-1. Characteristics Of One-Way Speaking Valves

Valve*	Type	Attachment To Trachs	Valve Characteristics
Passy-Muir speaking valve Passy-Muir, Inc.	One-way valves, #005 for tracheostomy use, #007 for ventilator use (only valve for ventilator)	Fits on 15 mm hub or can be placed in line with ventilator tubing	One-way silastic membrane with biased closed position—opens on inspiration. Creates positive closure feature.
Montgomery Boston Medical Products, Inc.	One-way valve	Fits standard 15 mm hub or Boston cannula system	Silicone membrane is hinged; maintains open position but opens more fully upon inspiration, closing upon expiration. Special cough release feature.
Trachoe ® distributed by BostonMedica Products, Inc.	Two types of fenestrated inner cannulas, which contain hinged valves	Tracheostomy tube with attachment that occludes inner cannula of tube. Two designs.	Tracheostomy tube is modified by the placement of an inner cannula that contains a one-way valve
Kistner One Way valve Philling-Weck	One-way valve	Fits Jackson metal tubes or Kistner plastic* tubes (made by Philling)	Hinged valve maintains open position, opening more fully upon inspiration, closing during expiration
Olympic "Talk Trach" Olympic Medical	T-shaped device that that fits on tracheostomy tube and can be attached to T-piece	Fits standard 15mm hub	Spring loaded valve mechanism maintains open position. Closes upon expiration to direct air into the upper airway.
Hood Hood Laboratories	One-way valve	Fits standard 15 mm hub	Valve contains a ball that moves, opening upon inspiration and closing upon exhalation

* All valves must be used with deflated tracheostomy tube cuffs.

(Table reprinted from Dikeman KJ, Kanandjan MS. Communication and Swallowing Management of Tracheostomized and Ventilator-dependent Adults. San Diego: Singular Publishing Group, Inc., 1995: 168, Table 5-8, with permission)

Guidelines for Decannulation

- Patients are ready for decannulation when they no longer need mechanical ventilation and can adequately clear airway secretions
- Patient should be evaluated for aspiration risk
- Should be able to cough secretions out of the tracheal tube
- Gradual cuff deflation allows weaning from cuffed to uncuffed TT. The cuffless TT is down sized to a smaller size and the patient evaluated for ability to cough secretions
- When the patient does not need excessive suctioning and the outer diameter of the TT is 8 mm., you may discontinue the TT or place a tracheal button temporarily

Tracheal buttons—extend only to the inner surface of the anterior tracheal wall without causing tracheal lumen obstruction. They are used when there is doubt about the success of the tracheostomy weaning. When plugged, the patient may breathe through the upper airway without resistance from the tracheostomy tube.

🕮 Another means of invasive ventilatory support is electrophrenic respiration with the use of a diaphragmatic pacer, used in patients with intact phrenic nerves and diaphragm. This is discussed in detail in the spinal cord injury chapter.

■ CARDIAC REHABILITATION

DEFINITION

Cardiac rehabilitation is the process by which persons with cardiovascular disease (including but not limited to patients with coronary heart disease) are restored to and maintained at their optimal physiological, psychological, social, vocational, and emotional status. (American Association of Cardiovascular and Pulmonary Rehabilitation–AACPR)

GOALS

The goal is to improve or maintain a good level of cardiovascular fitness, thereby returning the individual to a normal and productive life.

- For those able to return to work:
  1. Return to productive employment as soon as possible
  2. Improve and maintain as good cardiovascular fitness
- For those not able to return to work:
  1. Maintain as active a life as possible
  2. Establish new areas of interest to improve quality of life
- Patient Education and Reduction of Coronary Risk Factors

Risk Factors for Coronary Artery Disease (CAD)	
Irreversible	**Reversible**
Age Male gender Family history of CAD Past history of CAD, PVD, CVA	Hypertension Cigarette Smoking Hypercholesterolemia Hypertriglyceridemia Diabetes Mellitus Obesity Sedentary lifestyle Type A personality