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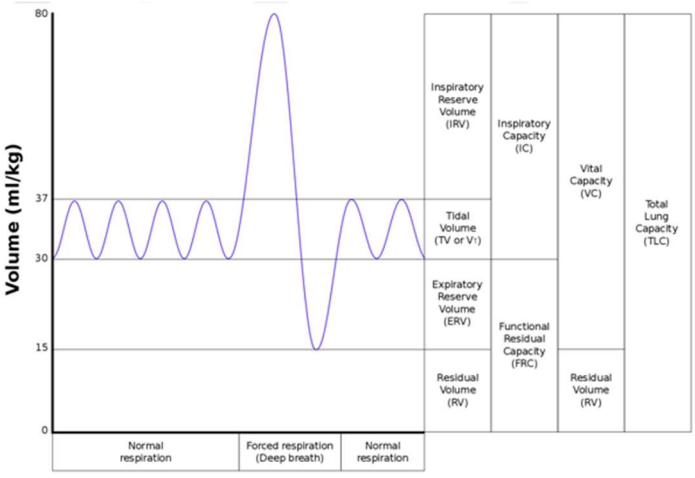
AAP BRS Podcast: Pulmonary Rehabilitation

Pulmonary function test (PFT):



https://commons.wikimedia.org/wiki/File:Lungvolumes.svg

Lung volumes:

Tidal volume (TV)
Volume of air moved during **normal** inhalation and exhalation.

Inspiratory reserve volume (IRV)
Maximum volume of air that can be inspired after the inspiration of a tidal volume.

Expiratory reserve volume (ERV)
Maximum volume of air that can be expired after the expiration of a tidal volume.

Residual volume (RV)
Volume of air remaining in the lungs after maximum forceful expiration.

Forced expiratory volume (FEV1)
Volume of air that can be forcefully expired in **one second** following a maximal inspiration.

Lung capacities:

Total lung capacity (TLC): **TLC = FRC + IC**
Total volume of air in the lungs after maximum inspiration when the lungs are completely full.

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

Forced vital capacity (FVC): **FVC = TV+ IRV + ERV.**
Vital capacity measured with the subject exhaling as rapidly as possible.

Functional residual capacity (FRC): **FRC= RV+ ERV**
Volume of air in the lungs at the end of normal expiration

Inspiratory capacity (IC): **IC = TV +IRV**
Maximum volume of air that can be inspired after reaching the end of normal expiration.

Obstructive and restrictive lung diseases:

Obstructive lung diseases	**Restrictive lung diseases**
Impaired gas exchange due to air trapping and loss of elastic recoil. **Causes:** • Chronic bronchitis • Emphysema • Cystic fibrosis • Asthma **Hyperinflated lungs with flattening of the diaphragm on chest X-ray** **Increased**: - Airway resistance - Expiratory effort - Respiratory muscle fatigue Air trapping leads to an **increase in RV** which results in **increased FRC and TLC. Other lung volumes are decreased** **FEV1 is DECREASED** GOLD Stages of COPD: -Mild: FEV1/FVC < 70% -Moderate: FEV1/FVC < 70% and predicted FEV1 50-79% -Severe: FEV1/FVC < 70% and predicted FEV1 30-49% -Very Severe: FEV1/FVC < 70% and predicted FEV1 <30%	Impaired lung ventilation due to decreased compliance of the lungs or chest wall **Intrinsic causes:** ↑ stiffness of lung tissue that restricts lung expansion • Sarcoidosis • Idiopathic pulmonary fibrosis • Silicosis **Extrinsic causes**: ↑ stiffness of the chest wall • Neuromuscular diseases (DMD, ALS) • Kyphoscoliosis • Ankylosing spondylitis • Cervical SCI **In cervical SCI**: reduced VC, retention of secretions, and autonomic dysfunction contribute to **respiratory dysfunction** **VC, TLC, RV, FRC, and FVC are ↓** **Exception**: **RV increases in cervical SCI** **FEV1 is NORMAL or increased**

Muscles of Respiration:

Inspiration
Primary muscles – Diaphragm, innervated by phrenic nerve (C3-5)
Accessory muscles– Sternocleidomastoid, trapezius, pectoralis major, scalene muscle, EXTERNAL intercostals **(I for E, E for I)**

Expiration
Primary muscles – Abdominal muscles
Secondary muscles – INTERNAL intercostals **(I for E, E for I)**

Goals of pulmonary rehabilitation:

1. Improving cardiopulmonary function by increasing AVO2 and VO2 max
2. Preventing and treating complications, such as infection
3. Increasing understanding of the disease
4. Improving the quality of life and the patient's ability to perform activities of daily life (ADLs), as well as facilitating return to work

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Comprehensive pulmonary rehabilitation:

1. Nutritional status evaluation

Respiratory muscle weakness is often associated with metabolic deficits. Optimize the patient from a nutritional standpoint, including electrolytes and protein intake and also evaluate for obesity.

2. Pharmacologic optimization

Assess and optimize the patient on appropriate medications, including any inhaled anticholinergics, beta-2 agonists, inhaled steroids, or other medications.

3. Supplemental oxygen therapy

Assess and equip with home oxygen, particularly if the patient is prone to desaturation during exercise below 90%. Emphasize smoking cessation.

4. Training in controlled breathing techniques

Controlled breathing exercises reduce dyspnea, reduce work of breathing, and improve respiratory muscle function and pulmonary parameters. Diaphragmatic breathing can increase TV and increase the maximum oxygen intake. Pursed-lip breathing can help decrease air trapping and improve gas exchange in the alveoli, thus decreasing the work of breathing in COPD patients.

5. Airway secretion elimination

Controlled cough, postural drainage, percussion therapy and teaching patients to follow a chest therapy program can help to clear airways. Postural drainage utilizes positioning to preferentially drain particular lung lobes and also optimize the blood flow to variable lobes.

6. Therapeutic exercises

Therapeutic exercises improve respiratory muscle endurance, strength, and efficiency. Inspiratory muscle exercises and training are key components of these exercises.

7. Reconditioning

Reconditioning exercises allow the patient to increase the ability to perform ADLs.

The patient is engaged in a progressive program with activities including aerobic conditioning (walking, swimming, jogging, or bicycling), ROM exercises (coordinated with diaphragmatic breathing) and upper extremity strengthening exercises.

A **daily 12-min walk** can help estimate exercise tolerance, and patients should keep a log of their times and distances during walks.

Upper extremity exercises help train the body to improve metabolic efficiency. Exercises should be performed to tolerance while closely monitoring the heart rate, and the patient may need to take rest if the heart rate exceeds **120/min**.

8. Energy conservation techniques and Rest

Energy conservation techniques include paced breathing, body mechanics, advanced planning and prioritizing activity and the use of assistive medical equipment.

Energy conservation techniques and rest are necessary to ensure the patients have a good balance of activity and recovery.

Rehabilitation of Restrictive lung disease:

Respiratory complications due to impaired secretion are the most common causes of death in advanced restrictive lung diseases.

A major focus of the rehabilitation process for restrictive lung disease is based on the prevention of complications and assistance with secretion management.

1. Patient education

Educate the patient on vaccinations and avoiding high-risk situations or crowds, sedatives, and excessive oxygen therapy.

2. Maintenance of adequate nutrition status

Optimize nutrition and avoid obesity or heavy meals.

3. Instructions in controlled breathing techniques

Teach glossopharyngeal breathing or deep breathing with insufflations. Glossopharyngeal breathing is a technique where patients use their pharyngeal muscles to project air boluses into the lungs. It can be used in the event of ventilator failures to sustain patients for a few hours, assuming their lungs are normal.

4. Secretion management techniques

Manually assisted cough, suctioning, or mechanical insufflator-exsufflator techniques assist with secretion clearance.

- Manually assisted cough can be used by placing the heel of the hand or arm at the anterior chest or abdomen and pushing in when the patient coughs to help generate expiratory cough force.
- Suctioning should be done in conjunction with other clearing techniques or when other techniques fail to remove secretions appropriately. Chest percussion or postural drainage may also be needed.
- Mechanical insufflator-exsufflator is the **most effective method for secretion clearance in paralyzed patients.** A deep inspiration (positive-pressure insufflation) is provided via a mask or through a tracheal tube, followed by rapid controlled suction (negative pressure exsufflation).

5. Use of non-invasive ventilation

Non-invasive ventilation decreases the energy expenditure of the respiratory muscles. This may be in the form of positive pressure, negative pressure, or a combination of both.

Intermittent abdominal pressure ventilators are devices that can provide positive pressure on the abdomen to assist diaphragmatic movement and promote expiration.

Rocking beds may also be used to capitalize on gravity to assist with ventilation.

Fick's equation:

VO2 max = (Heart rate x Stroke volume) x AVO2 difference

AVO2 difference (Arteriovenous Oxygen Difference) is the difference in the oxygen content between arterial blood and venous blood. It's a measure of the amount of oxygen that is taken up by the body's tissues.

VO2 max (Maximal oxygen consumption) is the maximal volume of oxygen that can be utilized in 1 minute during maximal or exhaustive exercise. It's a measure of cardiovascular fitness and endurance.

Patients benefit from pulmonary rehabilitation by increasing their AVO2 difference. This will increase VO2 max, endurance, and work capacity.