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Lung Function Tests: A Synopsis for The Uninitiated

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Summary

Herein, we aimed to review the main contents of Lung function tests (LFTs) that include spirometry, diffusion factor measurement, bronchial provocation tests, plethysmography, and forced oscillation techniques. LFTs are performed to examine patient's respiratory function and offer a variety of clinical uses in diagnosing and monitoring respiratory diseases, such as chronic obstructive pulmonary disease (COPD), interstitial lung diseases (ILD), and asthma. There are specific indications for LFTs that are described below and consist mainly of symptoms from respiratory system, abnormal imaging, monitoring of known pulmonary disease and investigation of treatment response, pre/meta-operative evaluation and lung transplantation. Additionally, the accuracy of LFTs relies on reference values combined with clinical history and overall presentation.

Narrative Review

Lung function tests (LFTs) or Pulmonary Function Tests (PFTs) encompass a series of clinical studies designed to assess lung capacity and any potential impairment of mechanical function within the lungs, respiratory muscles, and the chest wall. These tests aid in the diagnosis of various lung diseases; gauging their severity, as well as evaluating the respiratory system's response to potential medical and therapeutic interventions [1].

LFTs enable physicians to assess the patient's respiratory function. Although these tests are considered reliable and precise, the outcomes can be influenced by the effort that a patient puts in. While LFTs do not offer a definitive diagnosis on their own, they are an integral part of the diagnosis, and when combined with medical history, physical examination and laboratory results, they assist clinicians in arriving at a diagnosis [2].

Spirometry, diffusion factor measurement, bronchial provocation tests, plethysmography, and forced oscillation techniques have demonstrated versatile clinical uses in diagnosing and monitoring various respiratory diseases, such as chronic obstructive pulmonary disease (COPD), interstitial lung diseases (ILD), and asthma to name a few [3].

Indications for LFTs Include-

Investigating a patient with symptoms or signs that suggest pulmonary disease, for example cough, wheezing, breathlessness, crackles or an abnormal chest x-ray.

Monitoring patients with a known pulmonary disease, for progression as well as to measure response to treatment. Known pulmonary diseases can include interstitial fibrosis, COPD, Asthma, as well as pulmonary vascular disease

Investigating patients with diseases that may have respiratory complications, such as connective tissue diseases or neuromuscular diseases

Preoperative evaluation, prior to lung resection, cardiothoracic surgery or abdominal surgery

Evaluating a patient's risk of lung diseases, especially in the setting of exposure to pulmonary toxins such as radiation, medication or occupation exposure.

Surveillance following lung transplantation to check for acute rejection, infection or obliterative bronchiolitis [2].

Lung function reference values differ for each patient. They are established based on anthropometric factors, including weight, height, age and sex [4,5].

The functional reserve capacity (FRC) is an important measurement to assess lung values. FRC represents the amount of gas remaining in the lungs at the end of a normal expiration of breath. It is determined by combining the values of expiratory reserve volume (ERV) and residual volume (RV).

ERV signifies the maximal amount of gas that can be exhaled after a normal tidal breath, while RV is the volume of gas remaining in the airways after a maximal exhalation.

Apart from ERV and RV, other significant measures include the tidal volume (TV) and inspiratory reserve volume (IRV). IRV denotes the maximum volume of gas that can be inhaled from the end inspiratory tidal breath. TV represents the volume of gas inhaled or exhaled with each breath during rest [6,7].

Static lung volumes are typically assessed using whole body plethysmography within a sealed body box. Alternative techniques to measure static lung volumes include nitrogen washout or helium dilution. It is important to note that static lung volumes cannot be obtained through spirometry.

Whole Body Plethysmography

During this procedure, the patient sits inside an airtight box and breathes in or out a specific volume, usually the FRC. Once the desired volume is reached, a shutter is activated to seal off the breathing tube. The patient then makes respiratory efforts against the closed shutter. The basis for these measurements and this test is Boyle's law, which states that at a constant temperature, the volume of a given mass of gas varies inversely with pressure. Consequently, the expansion of the patient's chest volume slightly decreases the overall volume of the box (excluding the person) leading to a slight increase in pressure within the box [8].

Thus, static lung volumes can be calculated either by measuring changes in pressure in a box with constant volume, or by assessing changes in volume in a box with constant pressure. Spirometry is one of the most easily available and useful tests to assess pulmonary function. Spirometers are classified into closed- and open-circuit spirometers. Closed-circuit spirometers are further sub-classified into wet and dry spirometers. Open-circuit spirometers, which are more commonly used at present, measure airflow, integrate results, and calculate the volume.

Spirometers are widely used in clinical settings. They do not require complicated instructions, and patients can innately understand the use. The results from spirometry are accurate, and easily reproducible, thus making it easy to track changes over time, as is done in chronic respiratory diseases [9,10].

Diffusion Factor Management or Carbon Monoxide Diffusion Capacity

DLCO is indicated to evaluate parenchymal and non-parenchymal lung diseases. It is used in conjunction with spirometry to get accurate results. The severity of obstructive lung diseases, restrictive lung diseases, PVD and preoperative risk can be assessed in this manner.

DLCO is measured using a test gas that contains a small amount of Carbon Monoxide. It reflects the capacity of lungs to carry out gas exchange in the bloodstream. It is diminished in chronic obstructive lung diseases such as emphysema, interstitial lung disease, pulmonary vascular disease and anemia [11, 12].

Bronchopulmonary Provocation Tests

There are many types of bronchoprovocation testing that can be used to assess airway responsiveness. The most common types of tests for bronchoprovocation testing and the accurate diagnosis of asthma are the pharmacologic challenge and the exercise challenge [13].

Methacholine, a derivative of acetylcholine is the most commonly used agent for bronchoprovocation testing. The test involves administering incremental doses of methacholine, ranging from approximately 0.03 mg/ml to 16 mg/ml. Before the test, baseline spirometry is performed and a diluent is aerosolized via nebulizer for at least one minute. After this, spirometry is repeated twice.

The dose of methacholine is gradually increased until a significant decrease in FEV1, greater than 20% is observed. This dose is known as the provocative dose or PD20. A methacholine PD20 of 8mg/ml or less is considered a positive result, indicating bronchial hyperresponsiveness. Conversely, a PD20 greater than 16 mg/ml is considered a negative test suggesting normal bronchial reactivity [14,15].

Pulmonary function tests play a crucial role in evaluating patients with suspected or diagnosed respiratory conditions. They are also valuable in assessing individuals before undergoing significant surgical procedures.

Accurate interpretation of these tests relies on understanding normal values. However, to arrive at an accurate diagnosis and assessment, clinicians must integrate the test results with the patient's clinical history and overall presentation [2].

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