

# **Lung Function Tests**

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## **Objective of the lecture.**

To describe to the students the tests conducted in assessing the functional status of the lungs.

## **Format of the lecture.**

1. Introduction of the Respiratory system
2. Indications for Lung Function tests
3. Methods of measuring Lung Function.
4. Spirometry
5. Interpretation of spirometry results
6. Lung Diffusion test
7. Lung Plethysmography

# Introduction.

## **Anatomy of the respiratory system.**

- Respiratory system made up of the organs responsible for **exchange of gases**, consists of:

1. Nose
2. Pharynx
3. Larynx
4. Trachea
5. Bronchi
6. Lungs

**The upper respiratory tract includes the:**

1. Nose
2. Nasal cavity
3. Ethmoidal air cells
4. Frontal sinuses
5. Maxillary sinus
6. Larynx
7. Trachea

**The lower respiratory tract includes:**

1. Lungs,
2. Bronchi,
3. Alveoli.

# Functions of the lungs.

Three aspects of pulmonary function:

1. **Ventilation,**
2. **Diffusion,**
3. **Perfusion.**

## **Ventilation.**

- Air exchange between alveolar spaces and the atmosphere.

## **Diffusion.**

- Movement of O<sub>2</sub> and CO<sub>2</sub> across alveolar capillary membranes.

## **Perfusion.**

- Blood flow through pulmonary vessels.



## Lung Function Tests (LFTs).

- Also called **Pulmonary Function Tests (PFTs)/ Lung Function Studies/ Airflow Assessment.**
- **Non-invasive** diagnostic tests that provide **measurable feedback** about the **function** of the lungs.
- Provide information in **diagnosis** of certain lung disorders.

## Prerequisites for LFT.

- Pt's **age, sex, height, weight, and ethnicity** recorded before testing.
- Above **basis** for calculating **predicted values**.

## **Classification of LFTs.**

Divided into **three** categories:

- 1. Lung volumes and capacities**
- 2. Airway flow rates**
- 3. Gas exchange (diffusion capacity)**

## Lung volumes and capacities.

- **Air containing compartments** measured to assess **air trapping (hyperinflation, overdistension)** or **reduction** in volume.
- **Ventilation** assessed ( movement of air into and out of the lungs).
  - Some medical conditions **interfere** with **ventilation**.
  - Conditions lead to **chronic lung disease**.

**Conditions interfering with normal ventilation**  
categorized as:

- 1. Obstructive**
- 2. Restrictive**

## Obstructive condition:

Difficulties in **air flowing out** of the lungs due to **increased airway resistance**, causing a **decreased** flow of air.

## Restrictive condition:

- Difficulties in **air flowing into** the lungs. Chest muscles **unable** to expand adequately, creating a disruption in air flow (**limitation in chest wall excursion**).

- When **ventilation** altered by **both increased** airway resistance and **limited** chest wall excursion, the defect termed a **combined** or **mixed** defect.

## Airway flow rates.

- Typically measurement of **instantaneous** or **average** airflow rates during a **maximal forced exhalation** to assess airway **patency** and **resistance**.
- Tests also assess responses to inhaled **bronchodilators/provocations**.



## Gas exchange (diffusion capacity).

- Measures the **rate of gas transfer** across the alveolar capillary membranes
- Monitor the **side effects** of drugs e.g. bleomycin (**antineoplastic**) or amiodarone (**antiarrhythmic**)- cause interstitial **pneumonitis** or **pulmonary fibrosis**.
- Diffusion capacity in the **absence** of lung disease (e.g. **anemia**) evaluated..

## Indications for LFTs.

1. **Detection of early stages of pulmonary or cardiogenic- pulmonary disease.**
2. **Differential diagnosis of dyspnoea.**
3. **Presurgical assessment** (e.g. ability to tolerate intraoperative anesthetics, especially during **thoracic** procedures)
4. **Evaluation of risk factors** for other diagnostic procedures.
5. **Detection of early** respiratory failure.
6. **Monitoring** progress of bronchopulmonary disease.

- 7. Periodic evaluation** of workers exposed to materials harmful to the respiratory system.
- 8. Epidemiologic studies** of selected populations to **determine risks** for or **causes of** pulmonary diseases.
- 9. Workers compensation** claims.
- 10. Monitoring** after pharmacologic or surgical intervention.

## **Examples of disorders that may be detected with LFTs:**

- 1. Allergies.**
- 2. Chronic lung conditions. (e.g. asthma, bronchiectasis, emphysema, and chronic bronchitis-treatable but not curable (Chronic Obstructive Pulmonary Diseases-COPD)).**
- 3. Asbestosis.**

4. **Chest trauma.** (e.g. fractured ribs or a recent surgical procedure).
5. **Restrictive airway conditions.** (e.g. scoliosis, pulmonary tumors, or inflammation or scarring of the chest wall).
6. **Respiratory infections.**
7. **Sarcoidosis.**

## 8. **Scleroderma.** (Thickening and hardening of the skin).

# Methods of measuring Lung Function:

1. Spirometry
2. Lung Diffusion studies.
3. Lung Plethysmography

## Spirometry.

- The **spirometer** measures:
  1. **Volume** of air breathed **in** and/or **out**.
  2. **Rate** the air can be **inhaled** and **exhaled** from the lungs.
- Measurements are recorded on a device called a **spirograph**.



3. Other **measurements** derived from **calculations** based on the results of certain **spirometry procedures**.
4. In addition, tests give **clues** on **oxygen** and **carbon dioxide diffusion** in the alveoli.

- **Normal values** for LFTs **vary** from person to person.
- Test results compared to the **expected** average in someone of the same **age, height, weight, sex, and race**.
- In addition, results compared to the **previous test** results, if done.

## Procedure for Spirometry:

1. Pt given a soft **nose clip** to apply during the procedure so that all of his/her **breaths** goes through his/her **mouth**.
2. Pt given a sterile mouthpiece attached to the **spirometer**.

4. Pt instructed to **perform** various breathing maneuvers (**inhaling** and **exhaling**).
5. Pt may be asked to **repeat** the maneuvers several times before the test is completed.
6. Pt **monitored** carefully during the procedure for **faintness, dizziness, dyspnoea**, or any other **complications**.

## Spirometry



## **Risks of Spirometry.**

May include:

- 1. Faintness or light-headedness due to hyperventilation.**
- 2. Asthmatic episode precipitated by deep inhalation exercises.**

## Contraindications.

1. Recent eye surgery.
2. Recent abdominal or chest surgery.
3. Chest pains.
4. Thoracic, abdominal, or cerebral **aneurysm**.
5. **Active** pulmonary tuberculosis or **acute** respiratory infection, such as a **cold**.

## **Factors or conditions interfering with the accuracy of Spirometry:**

- i. Medications such as bronchodilators/analgesics.**
- ii. Pregnancy/ abdominal distention .**
- iii. Fatigue or other conditions.**



## Readings.

- **Common values** that may be measured during spirometry include:
  1. **Tidal volume ( $V_T$ ):** Volume of air inhaled or exhaled during **normal** breathing.
  2. **Minute volume (MV):** Total volume of air **exhaled** per minute.
  3. **Vital capacity (VC):** Total volume of air **exhaled** after **maximum inspiration**.

4. **Functional Residual Capacity (FRC):** Volume of air remaining in lungs after **normal** expiration.
5. **Total lung capacity:** Total volume of lungs when **maximally inflated**.
6. **Forced vital capacity (FVC):** Volume of air exhaled **forcefully** and **quickly** after **maximum inspiration**.

7. **Forced Expiratory Volume (FEV):** Volume of air expired during the 1<sup>st</sup> , 2<sup>nd</sup> , and 3<sup>rd</sup> seconds of the **FVC test**.
8. **Forced Expiratory Volume in One Second (FEV1):** volume of air which can be forcibly **exhaled** from the lungs in the **first second** of a forced **exhalation**.

**9. FEV1/FVC Ratio [FEV1% or %FEV1]:**  
Ratio of FEV1 to FVC, giving the **percentage** of the total volume of air **exhaled** from the lungs during the **first** second of forced **exhalation**.

**10. Peak expiratory flow rate (PEFR):**  
Maximum flow of expired air during an FVC.

**11. Forced Expiratory Flow (FEF):** A measure of **how much** air can be **exhaled** from the lungs.

**12.FEF<sub>25%</sub>** : Volume of air that can be **forcibly exhaled** from the lungs in the first **25%** of the **FVC** test.

**13.FEF<sub>50%</sub>** : Total volume of air **expelled** from the lungs during the **first half (50%)** of the **FVC** test.

**14.FEF<sub>25%-75%</sub>** : Total volume of air **exhaled** from the lungs during the **middle half** of the **FVC** test.

**15.Maximal Voluntary Ventilation (MVV)** : Value determined by having the pt **inhale** and **exhale** as **rapidly** and **fully** as possible in **12 seconds**.

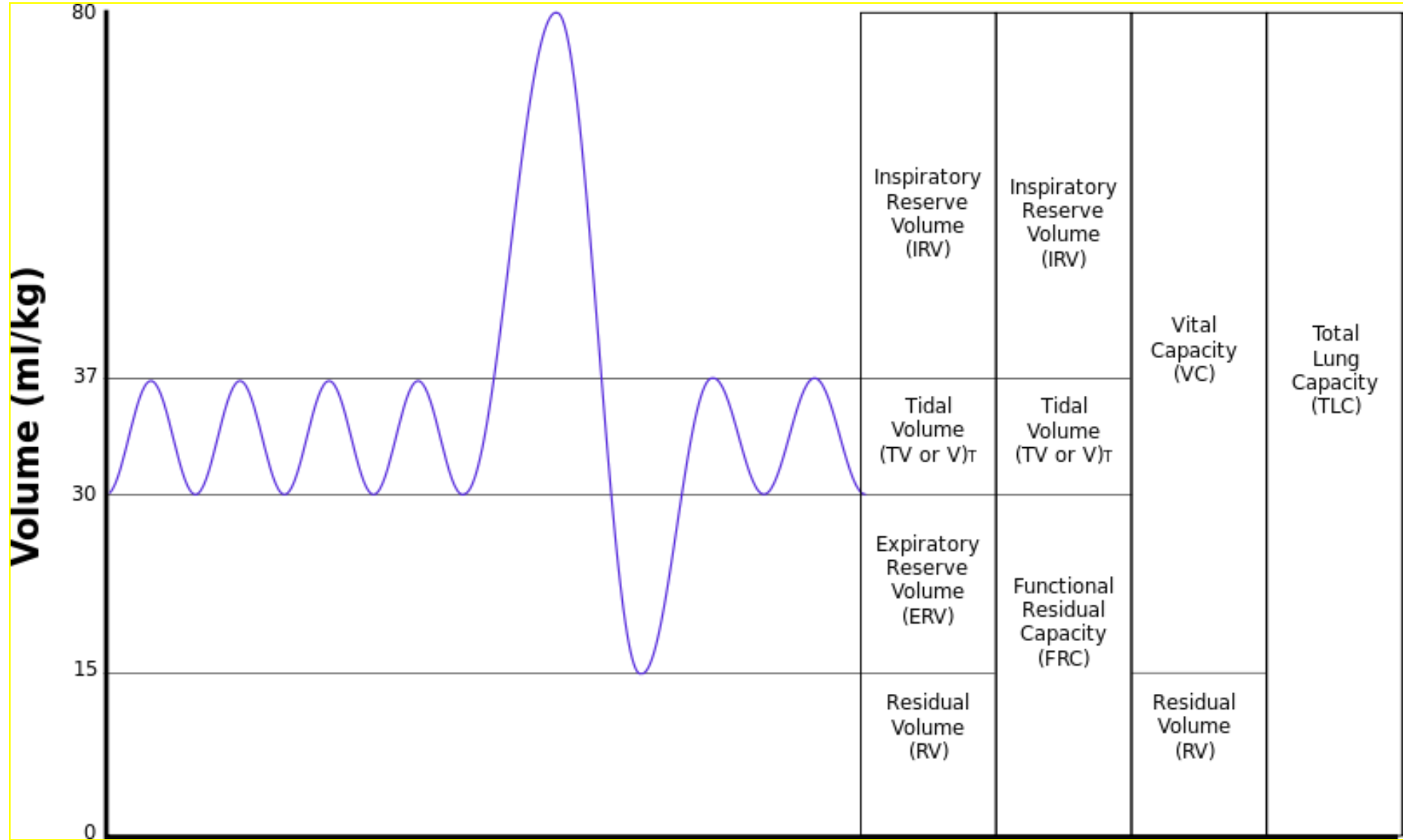
**16. Inspiratory Reserve Volume (IRV):**  
maximum volume of air that can be  
inspired from end-tidal inspiration  
(Complemental air).

**17. Expiratory Reserve Volume (ERV):**  
maximum volume of air that can be  
expired from end-tidal expiration.

**18. Residual Volume (RV):** The volume of air remaining in the lungs after **maximal expiratory** effort [**Residual air, Residual capacity**].

**19. Inspiratory Capacity:** The sum of **IRV** and **TV**.





## Interpretation of spirometry results.

- **One** of the ways of interpreting the results:

**Step 1:** First, check the **FVC**  
[normal/abnormal].

**Step 2:** Next, check **FEV1** [normal/abnormal].

**Step 3:** If both FVC and FEV1 are **normal**, the test is **normal test** -discontinue analysis of results.

**Step 4:** If FVC and/or FEV1 are **low**, - indicate a **lung disease** and further tests are needed to evaluate this.

- **Step 5:** Finally, if Step 4 suggests a possibility of lung disease, check the **% predicted** for the **FEV1/FVC**.
- If  $\leq 69\%$ , an **obstructive disease** suspected.
- If  $\geq 85\%$ , a **restrictive lung disease** suspected.

# Average lung volumes and capacities in healthy adults\*.

- Volumes
- Capacities

## Lung Diffusion test \*.

- Diffusing capacity of the lungs for **carbon monoxide**.
- The goal is to determine well oxygen diffuses from the alveoli to the blood stream.

# Procedure of Lung Diffusion Test

- Before the Test is done, the patient must have stayed 4 -6 hours without smoking, or a heavy meal and they must report if they are using any Bronchodilator
- A measured amount of CO is inhaled and the breath is held for 10s.
- Breath as fast as possible into another container and measure the amount

## Lung Plethysmography\*.

- Variations in lung volume



**FIN**