

Title: Spirometry

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I. Measurements of Ventilation – Spirometry

A. Pulmonary Volumes

- 1. The tidal volume (TV)** is the volume of air that is inspired or expired with each normal breath (about 500 milliliters).
- 2. The inspiratory reserve volume (IRV)** is the maximum volume of air that can be inspired with a maximal inspiratory effort *in excess of the normal tidal volume* (about 3000 milliliters).
- 3. The expiratory reserve volume (ERV)** is the maximum volume of air that can be expired *from the resting–end expiratory level by an active expiratory effort* (about 1100 milliliters).
- 4. The residual volume (RV)** is the volume of air that remains in the lungs *after the most forceful expiration* (about 1200 milliliters).

B. Pulmonary Capacities - include two or more pulmonary volumes.

- 1. The vital capacity (VC)** is the maximum volume of air that can be expired *from the point of maximum inspiration* (about 4600 milliliters).

$$\mathbf{VC = IRV + TV + ERV}$$

- 2. The inspiratory capacity (IC)** is the maximum volume of air a person can breathe in *from the resting–end expiratory level* (about 3500 milliliters).

$$\mathbf{IC = IRV + TV}$$

- 3. The functional residual capacity (FRC)** is the volume of air that remains in the lungs *at the end of normal expiration* (about 2300 milliliters).

$$\mathbf{FRC = ERV + RV}$$

4. The total lung capacity (TLC) is the volume of air contained in the lungs *at the end of maximum inspiration* (about 5800 milliliters).

$$\text{TLC} = \text{IRV} + \text{TV} + \text{ERV} + \text{RV}$$

$$\text{TLC} = \text{VC} + \text{RV}$$

$$\text{TLC} = \text{IC} + \text{FRC}$$

C. The role of FRC (normal breathing) and RV (depeest breathing) is to act as *a buffer against extreme changes in alveolar oxygen and carbon dioxide partial pressures.*

D. Measurement of RV, FRC, and TLC is impossible by a direct method /spirometry/ !

E. Pulmonary volumes and capacities are affected by physical characteristics, such as sex, age, height and weight, and sporting activity. Its only by comparison with normal values predicted according to physical characteristics, that it is possible to evaluate the results obtained by pulmonary function tests.

F. Pulmonary Function Tests

1. **The vital capacity test** is performed to determine the vital capacity (VC) and it's volume compartments (TV, ERV, and IRV).

2. **The forced (expiratory) vital capacity test is used to determine the airway resistance and to detect airway obstruction.** Several measurements are obtained by the FVC maneuver, such as:

a. **The forced (expiratory) vital capacity (FVC).**

b. **The forced expiratory volume during the first second (FEV₁)**

c. **FEV₁/FVC [%] ratio.**

3. **FEV₁ (FVC test) is additionally referred to VC (VC test) to calculate FEV₁/VC [%] ratio.**

II. Presentation and Interpretation of Pulmonary Function Tests Obtained by Means of Spirometry. Interpretation Algorithm.

There are two major categories of lung disorders that affect the results obtained by pulmonary function tests: **restrictive changes and obstructive changes**.

1. **The restrictive changes** are found in lung and/or chest abnormalities, which cause a decrease in the amount of normally ventilated lung tissue. They include *pleural diseases, alveolar filling processes, interstitial diseases, or may be present because of thoracic cage abnormalities, obesity, or neuromuscular involvement of the respiratory muscles.*

a. **Results of VC test: decreased** all lung volumes and capacities (\downarrow VC, \downarrow IRV, \downarrow TV, \downarrow ERV)

b. **Other changes (calculated):** \downarrow RV, \downarrow FRC, \downarrow TLC

c. **Results of FVC test:**

- **\downarrow FVC, \downarrow FEV₁, normal or increased FEV₁/F(VC)[%] ratio**

2. **The obstructive changes** are characterized by increased airway resistance. The most common reason of lower airway obstruction is *asthma* or *COPD - chronic obstructive pulmonary disease, which includes chronic bronchitis and emphysema.*

a. **Results of VC test and RV calculation depend on how severe is the obstruction:**

- **Mild obstruction: normal VC, normal RV, normal TLC** or
- **Severe obstruction (air trapping):** \downarrow VC, \uparrow RV, \uparrow FRC, \uparrow TLC (hyperinflation)

b. **Results of FVC test:**

- **\downarrow FEV₁, \downarrow or normal FVC, and decreased FEV₁/F(VC)[%] ratio**

The primary indicator of airflow obstruction is reduced FEV₁ and FEV₁/F(VC) percentage.

3. **Mixed changes (obstruction and restriction)** may be present if *reduced FEV₁ and FEV₁/F(VC)[%] ratio is associated with reduced VC. Then concurrent restriction cannot be excluded. To distinguish between severe but pure obstruction or mixed changes one can determine the total lung capacity (TLC).*

4. Less common *obstruction of upper airway, trachea, or large bronchi* may be suggested by spirometry. It is categorized into *fixed* and *variable* obstruction (where airflow is compromised by dynamic changes in airway diameter).