

# RS MODULE

## SPIROMETRY

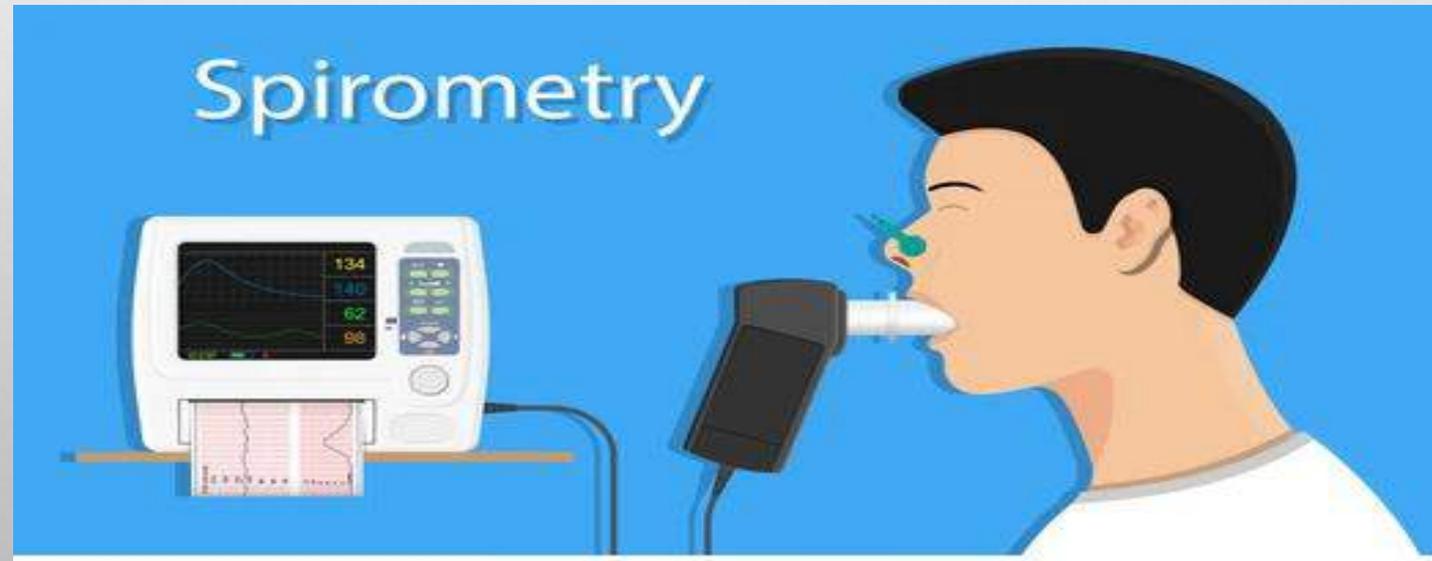
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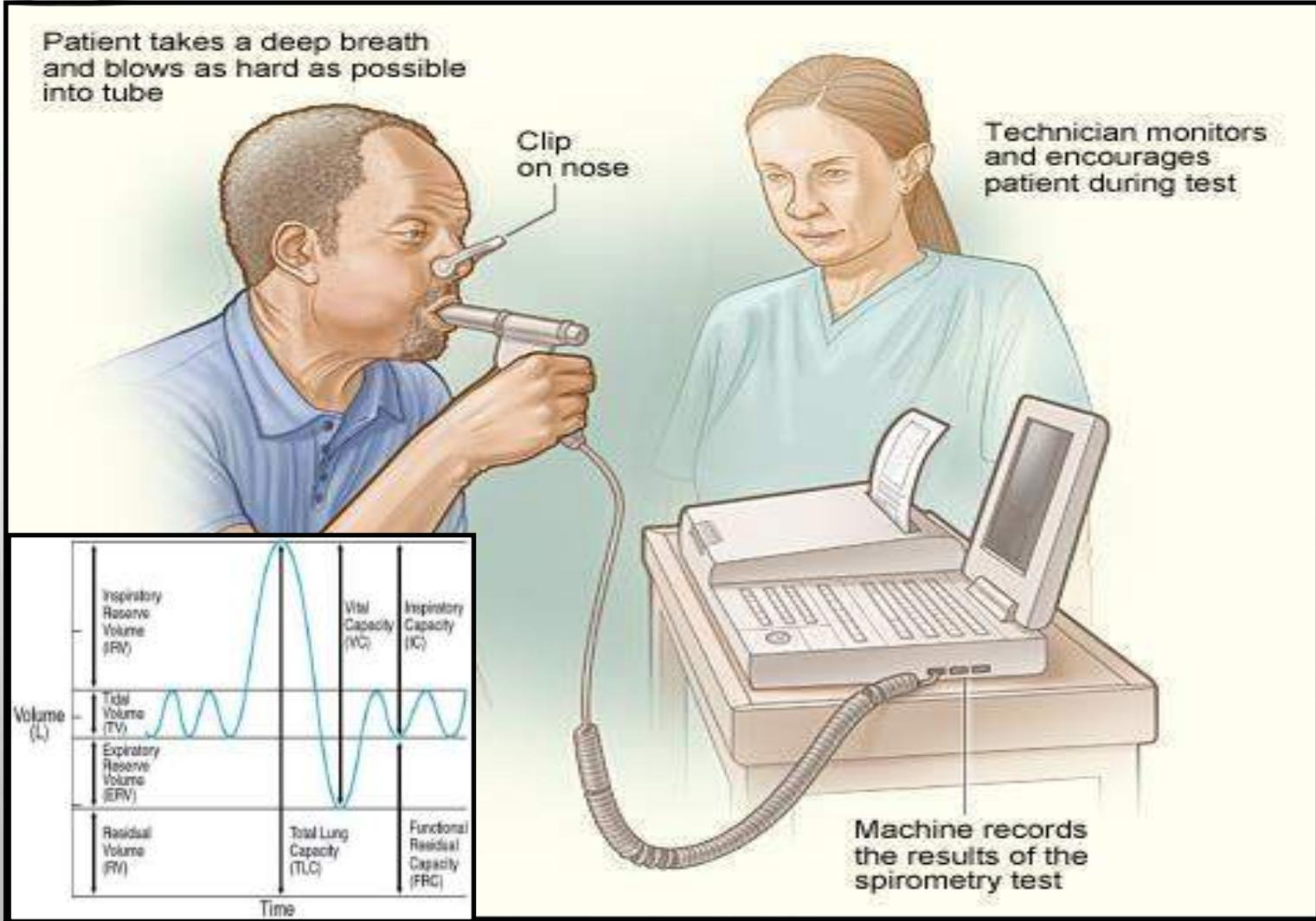
# SPIROMETRY

- ✓ It is the first lung (pulmonary) function test done.
- ✓ It means measurements of lung volumes and capacities.

## **Indication:**

- ✓ Diagnosis of lung diseases.

For this test, the subject breathe into a mouth piece attached to a recording device called (**spirometer**).

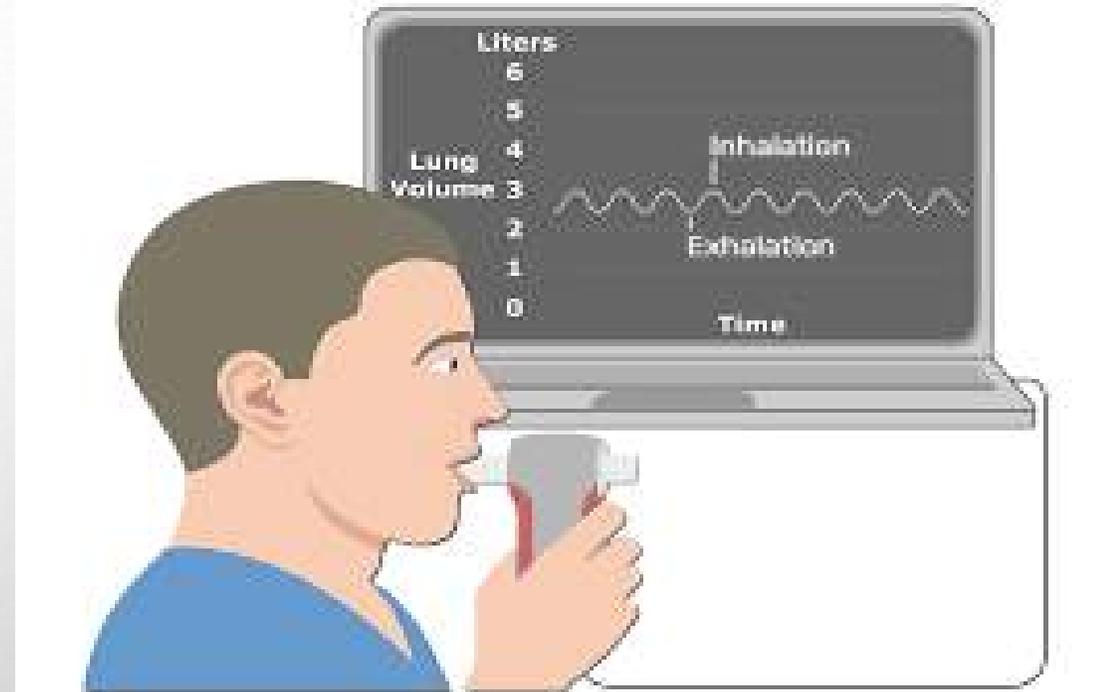


**Figure 13.9 The Spirometer** Pulmonary function testing involves multiple instruments and techniques. One basic instrument is the spirometer. The subject breathes in and out of a tube, resulting in vertical displacement of the inner canister, which floats upside down in water. The recorded tracing is analyzed to obtain several basic lung volumes and capacities (see Fig. 13.10).

# Spirometer

# SPIROMETRY SPIROMETER SPIOGRAM

- Respiratory volumes are **dependent** on a person's age, sex, physical build, and general health.
- **Spirometry** is used for **measuring both static and dynamic lung volumes and capacities.**
- Spirometry data are **helpful** in the **diagnosis** of respiratory diseases.
- **N.B. Lung capacity is the sum of two or more lung volumes.**



# Static lung volumes

## 1. Tidal volume (TV):

- It's the **volume of air inspired or expired by normal inspiration or expiration (eupnea)**.
- It is about **500 ml**.

## 2. Inspiratory reserve volume (IRV):

- It's the **volume of air inspired by maximum deep inspiration after normal inspiration** (i.e. Tidal volume is excluded).
- It is about **3000 ml**.

## 3. Expiratory reserve volume (ERV):

- It's the **volume of air expired by maximum deep expiration after normal expiration** (i.e. Tidal volume is excluded).
- It is about **1200 ml**.

## 4. Residual volume (RV):

- It's the **volume of air remaining in the lung after maximum deep expiration.**
- It is about **1200 ml.**
- **RV can't be measured by spirometry.** It is measured by **Helium Dilution Method.**
- This volume of air is lost when the thoracic cavity is opened and the -ve IPP is no longer present.

# Static lung capacities

## **1. Inspiratory capacity (IC):**

- It's the volume of air inspired by maximum deep inspiration from midthoracic position (i.e. Tidal volume is included).
- It equals  $TV + IRV = 500 + 3000 = \text{about } 3500 \text{ ml.}$

## **2. Functional residual capacity (FRC):**

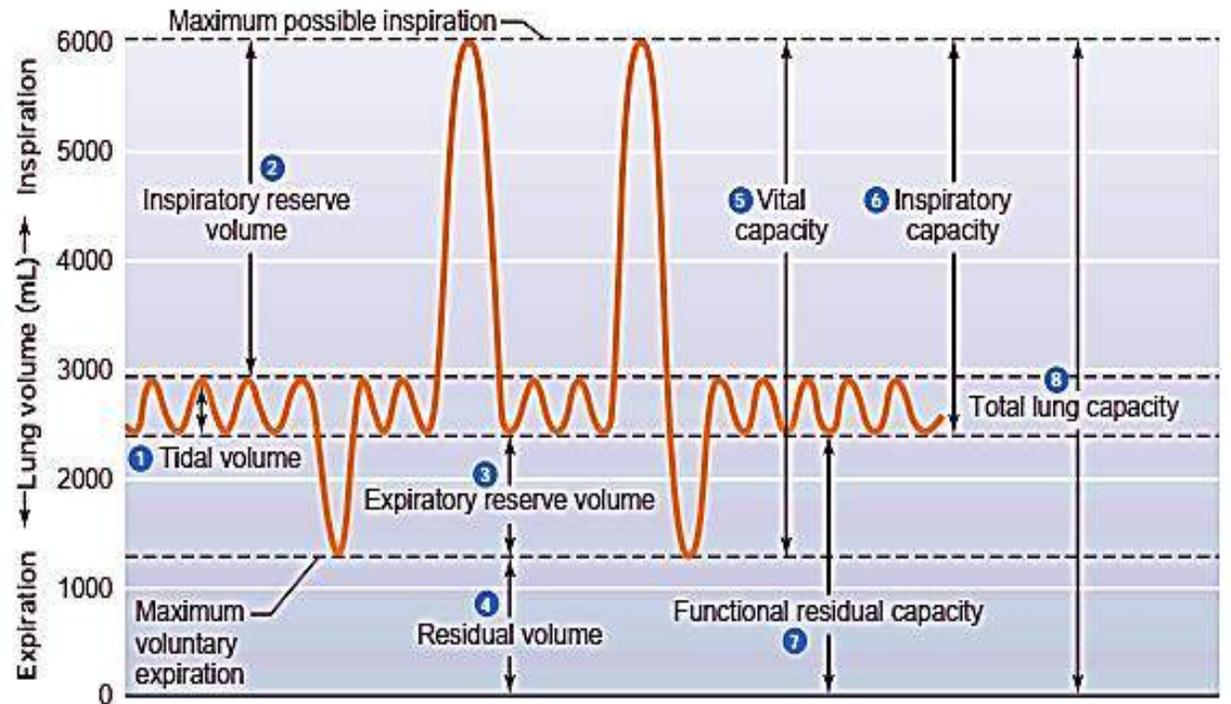
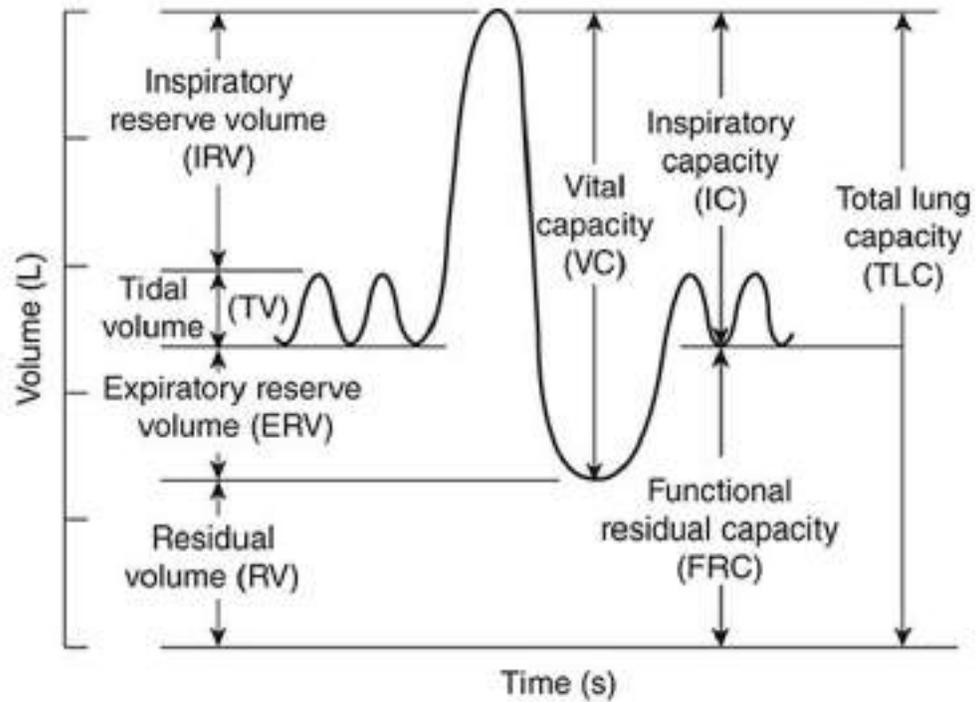
- It's the volume of air present in the lungs after normal expiration.
- It equals  $ERV + RV = 1200 + 1200 = \text{about } 2400 \text{ ml.}$
- It can't be measured by the spirometer as it can't measure the **RV**.

### 3. Vital capacity (VC):

- It's the volume of air expired by maximum deep expiration after maximum deep inspiration.
- It equals  $TV + IRV + ERV = 500 + 3000 + 1200 = \text{about } 4700 \text{ ml}$ .

### 4. Total lung capacity (TLC):

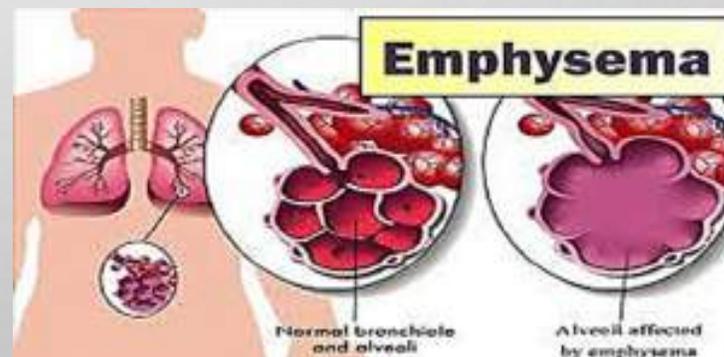
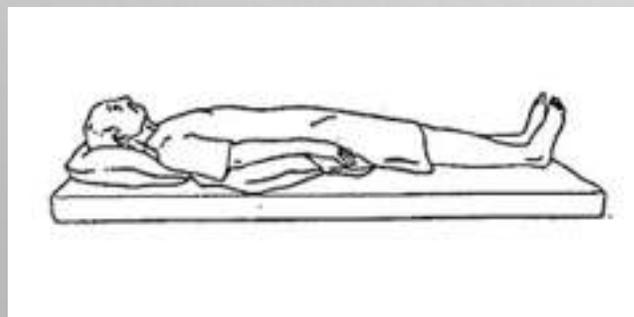
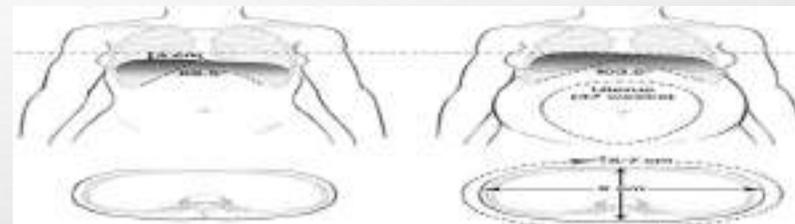
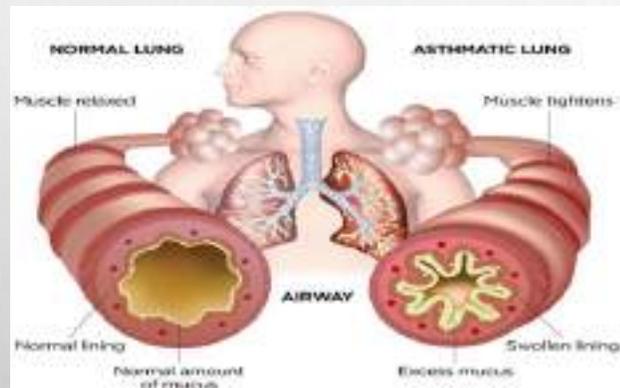
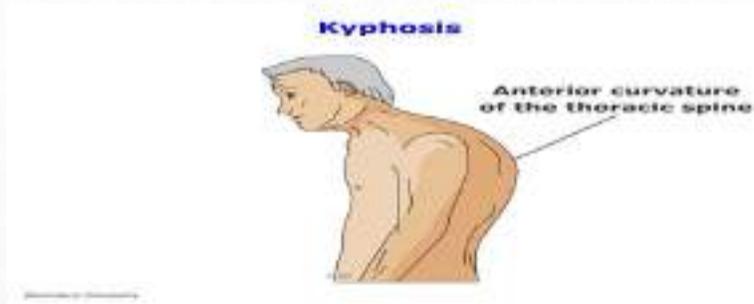
- It's the volume of air present in the lungs after maximum deep inspiration.
- It includes all lung volumes ( $TV + IRV + ERV + RV$ ) **OR** ( $VC + RV$ ) =  $4700 + 1200 = \text{about } 5900 \text{ ml}$ .
- It can't be measured by the spirometer (as it can't measure the **RV**).



# Spirogram



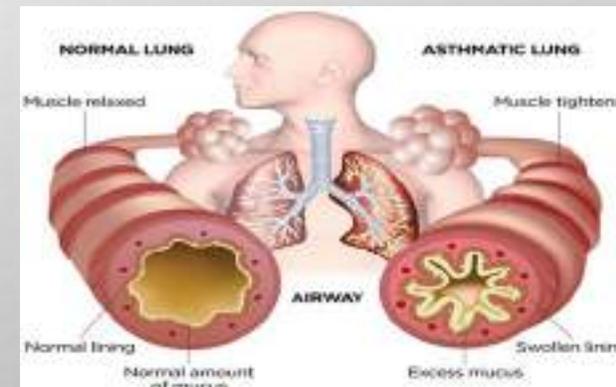
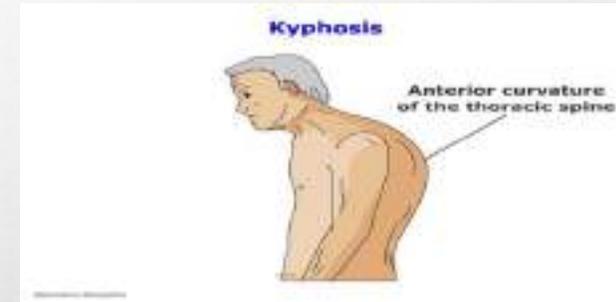
# FACTORS AFFECTING VITAL CAPACITY (VC)



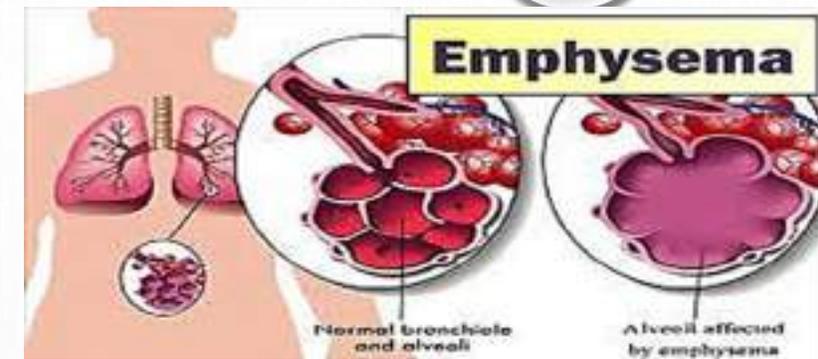
**A) Muscle strength:** VC is greater in athletes with stronger muscles than in sedentary people.

**B) Mobility of chest wall and movement of diaphragm:** Any deformity in the bones of the chest (**kyphosis**) or any abdominal swellings that limit diaphragm descent (as in pregnancy or ascites) lead to decrease in VC.

**C) Patency of airways:** Decreasing the patency of airways lead to decrease in VC (as in bronchial asthma).

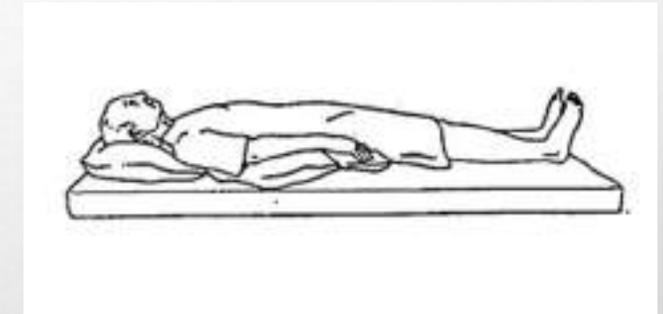


**D) Elasticity of the lungs:** Decreased lung elasticity also decreases VC (as in emphysema in smokers).



**E) Body posture:** VC is higher in standing or sitting positions than in recumbent position due to:

- ✓ In recumbent position: abdominal viscera push the diaphragm upwards.....limits its descent..... decrease VC.
- ✓ In recumbent position: increased venous return..... lung congestion with blood.....decrease air entering the alveoli .....decrease VC.
- ✓ Pulmonary congestion as in **left ventricular failure** ..... Decreases VC specially in recumbent position.



# Dynamic lung volumes & capacities

- The term dynamic refers to lung volumes or capacities measured in relation to unit of time.
- Includes:
  - 1) Timed Vital Capacity (TVC) or (Forced Expiratory Volume; FEV).
  - 2) Ratio of FEV1/VC.
  - 3) Minute ( total ) Ventilation ( $V_E$ ).
  - 4) Alveolar (effective) Ventilation ( $V_A$ ).
  - 5) Maximum Breathing Capacity (MBC) or Maximum Voluntary Ventilation (MVV).
  - 6) The Breathing Reserve (BR).

## 1. Timed vital capacity (TVC) or (Forced expiratory volume; FEV):

- The vital capacity is a **nonspecific pulmonary function test** due to its affection by many factors.
- In bronchial obstruction, the vital capacity may be normal but the duration of expiration is prolonged.
- To take the expiration time into consideration, the timed vital capacity (TVC) is measured where the forced expiratory volume (**FEV is measured every second** during forced expiration till the end of expiration).

- Normally, the **FEV** is completely expired in about **four seconds** as follows:
  - **FEV1** = forced expiratory volume after the **first second** is about **83 %** of the total VC. (Average is about 80% of VC).
  - **FEV2** = forced expiratory volume after the **second second** is about **94 %** of the total VC.
  - **FEV3** = forced expiratory volume after the **third second** is about **97%** of the total VC.
  - **FEV4** = forced expiratory volume after the **fourth second** is about **100%** of the total VC.



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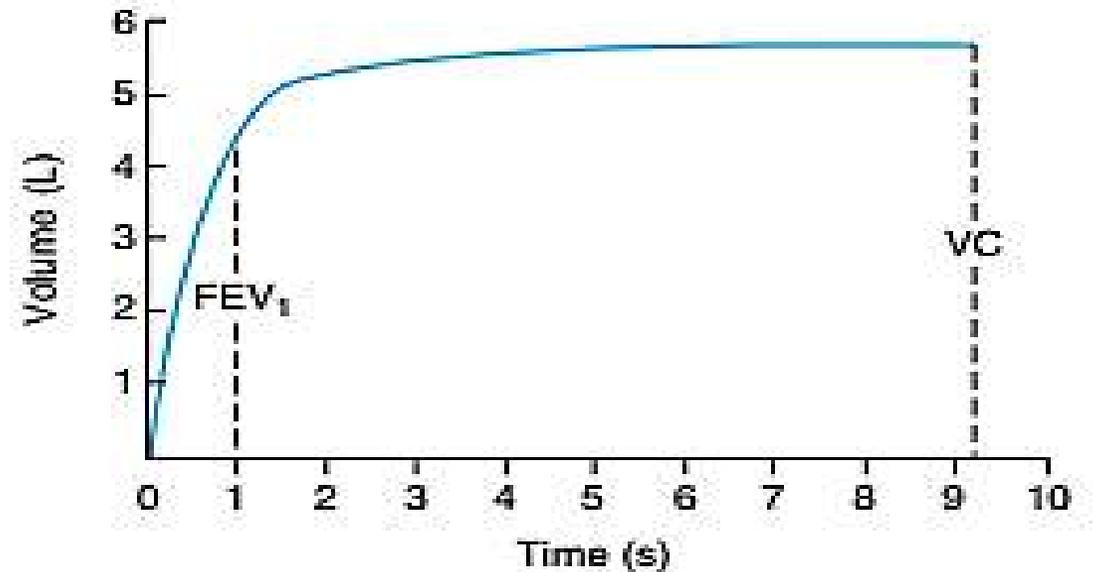
# N.B.

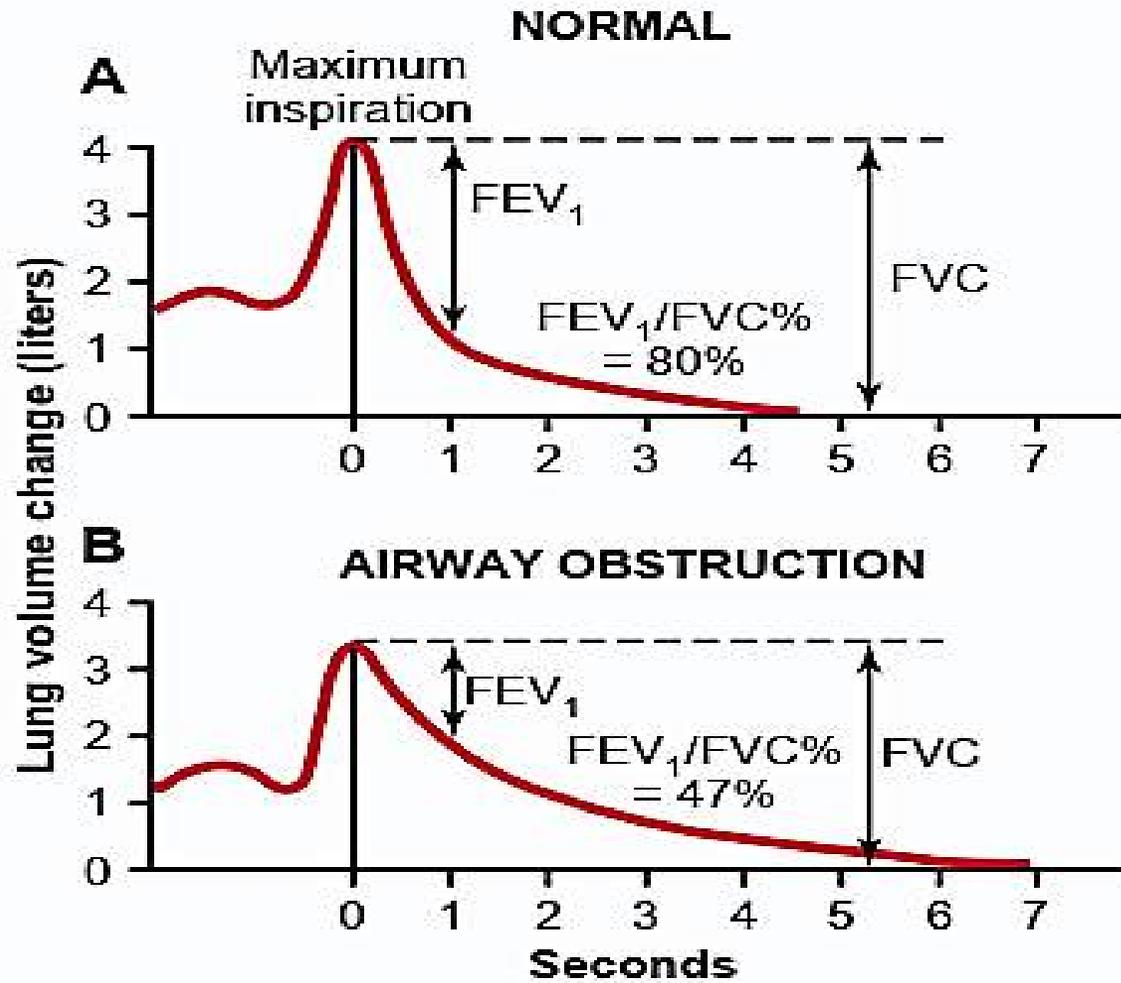
In obstructive lung diseases, (e.g. in bronchial asthma),

- ✓ Although the vital capacity (i.e. VC) may be normal.
- ✓ The timed vital capacity; FEV1 is markedly reduced.

## 2. Ratio of FEV1/VC:

- It is calculated by dividing the volume of FEV expired in the 1st second (FEV<sub>1</sub>) by the total VC.
- Normally about **0.8** (i.e. 80%)
- **Decreased** in **obstructive** lung diseases (e.g. **Asthma**) .





### 3. Minute ventilation ( $V_E$ ):

- It is the volume of air breathed/minute.
- =  $TV \times \text{respiratory rate} = 500 \times 12 = \mathbf{6000 \text{ ml (6L) /minute.}}$

### 4. Alveolar ventilation ( $V_A$ ):

- It is the volume of air that enters the **alveoli** and undergoes **gas exchange with blood/minute.**
- $EV = (\text{tidal volume} - \text{dead space}) \times \text{respiratory rate.}$   
 $= (500-150) \times 12 = 350 \times 12 = \mathbf{4200 \text{ ml (4.2L) /minute.}}$

# Significance:

- **The  $V_A$  is more significant than  $V_E$ .**

In shallow rapid breathing (**Tachypnea**), the **rate of respiration may be doubled 24 cycle/minute**, the **tidal volume is decreased, may be 250 ml**, accordingly,

- The minute ventilation will be  $250 \times 24 = 6000$  ml/minute (i.e. Normal), while alveolar ventilation will be;  $(250-150) \times 24 = 2400$  ml/minute, which is very much reduced as compared to normal values.

## 5. Maximum breathing capacity (MBC) or maximum voluntary ventilation (MVV):

- It is **the maximal volume of air breathed/ minute** when respiration is as **fast** and as **deep** as the person can.
- **Measurement:**

We ask the person to breathe as rapid and as deep as he can (i.e. Maximal effort) for **1/4 of a minute**.

**Then, the volume of air breathed during this time is multiplied by 4 to calculate the volume of air during a whole minute.**

### Normal values of MBC:

- In **adult males**, it is about **80-160 L /minute**.
- In **adult females**, it is about **60- 120 L/minute**.

N.B.

- We cannot allow the subject to do the maximal effort for a whole minute. WHY?



As this hyperventilation leads to  $\rightarrow$  excessive wash of  $\text{CO}_2$   
 $\rightarrow$  Hypocapnia and alkalosis and may be tetany.

## 6. The breathing reserve (BR):

**BR = Maximum breathing capacity (MBC) - Minute ventilation ( $V_E$ ).**

### Significance:

- **Used for calculation of dyspneic index (DI).**
- **The dyspneic index (DI) =**

$$\frac{\text{BR}}{\text{MBC}} \times 100\%$$

- Normally, **DI** is about **90 %**.
- when **D.I. < 70 %**, dyspnea occurs on slight effort.

# RECALL INFORMATION

## The Importance of Spirometry



▶ ≡

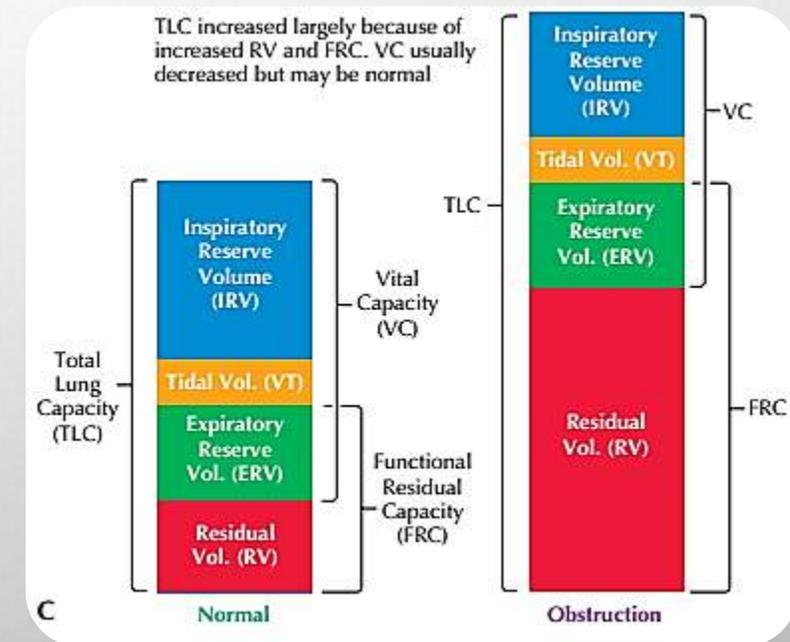
Obstructive Restrictive

lung Disease

An anatomical diagram of the human respiratory system, showing the trachea, bronchi, and lungs. The diagram is positioned between the words 'Obstructive' and 'Restrictive' in the text above. The word 'lung' is underlined in purple.

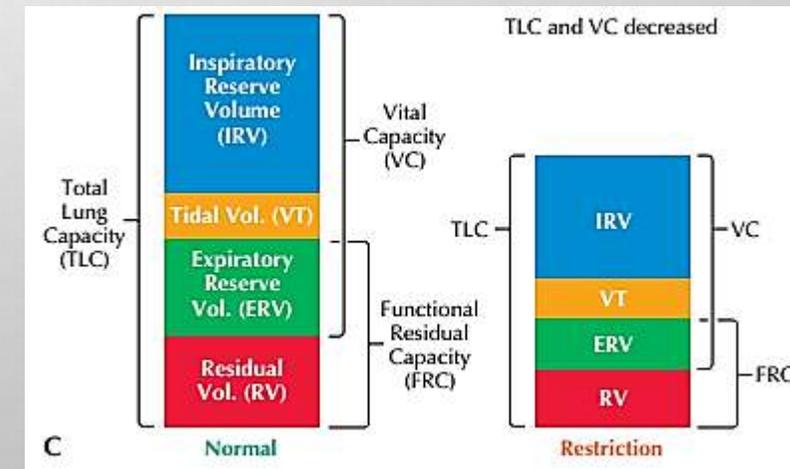
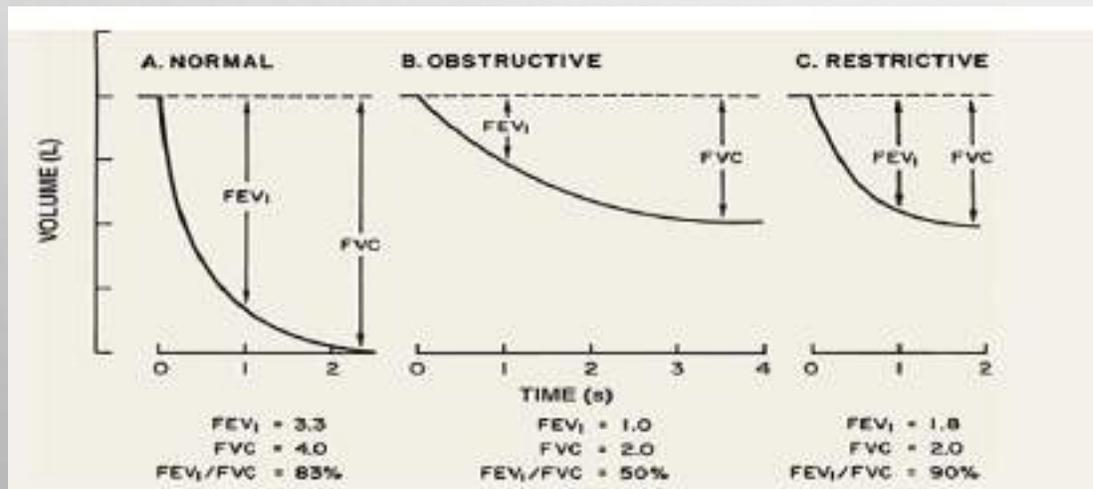
## Obstructive lung diseases:

- Also, they are referred to as chronic obstructive pulmonary diseases or COPD (e.g. Emphysema and chronic bronchitis) and asthma.
- These diseases are characterized by **air outflow obstruction (with/without inflow obstruction)** and subsequent **air trapping within the lungs**.
- Pulmonary function testing (PFTs) shows;
  1. A markedly decreased FEV1 and decreased VC (may be normal).
  2. **The hallmark of obstructive lung disease is a decreased FEV1/VC ratio.**
  3. **RV, FRC and TLC are increased because of air trapping.**



# Restrictive lung diseases:

- Restrictive lung diseases may be caused by either **pulmonary causes (i.e. Lung fibrosis as TB)** or **extrapulmonary causes (e.g. Chest deformity as kyphosis)**.
- They are characterized by **reduced lung expansion (i.e. Decreased lung volume)**.
- RV and TLC are decreased.
- FEV1 and VC are also decreased.
- FEV1 and VC decrease proportionately, resulting in a normal FEV1/VC, or sometimes VC is decreased to a greater degree than FEV1, resulting in an increased FEV1/VC.**





Thank you

A decorative graphic featuring the words "Thank you" in a black, elegant cursive font. The text is centered within a white, cloud-like shape with soft, wavy edges. This central element is surrounded by a vibrant floral wreath. The wreath includes several large orange flowers with dark brown centers, a yellow flower with a green center, and clusters of small pink flowers. Green leaves and stems are interspersed throughout the arrangement. The entire graphic is set against a light gray background with rounded corners. The overall image has a soft, watercolor-like aesthetic, with several realistic water droplets scattered around the central graphic, particularly in the top-left and bottom-right corners.