RS MODULE

SPIROMETRY

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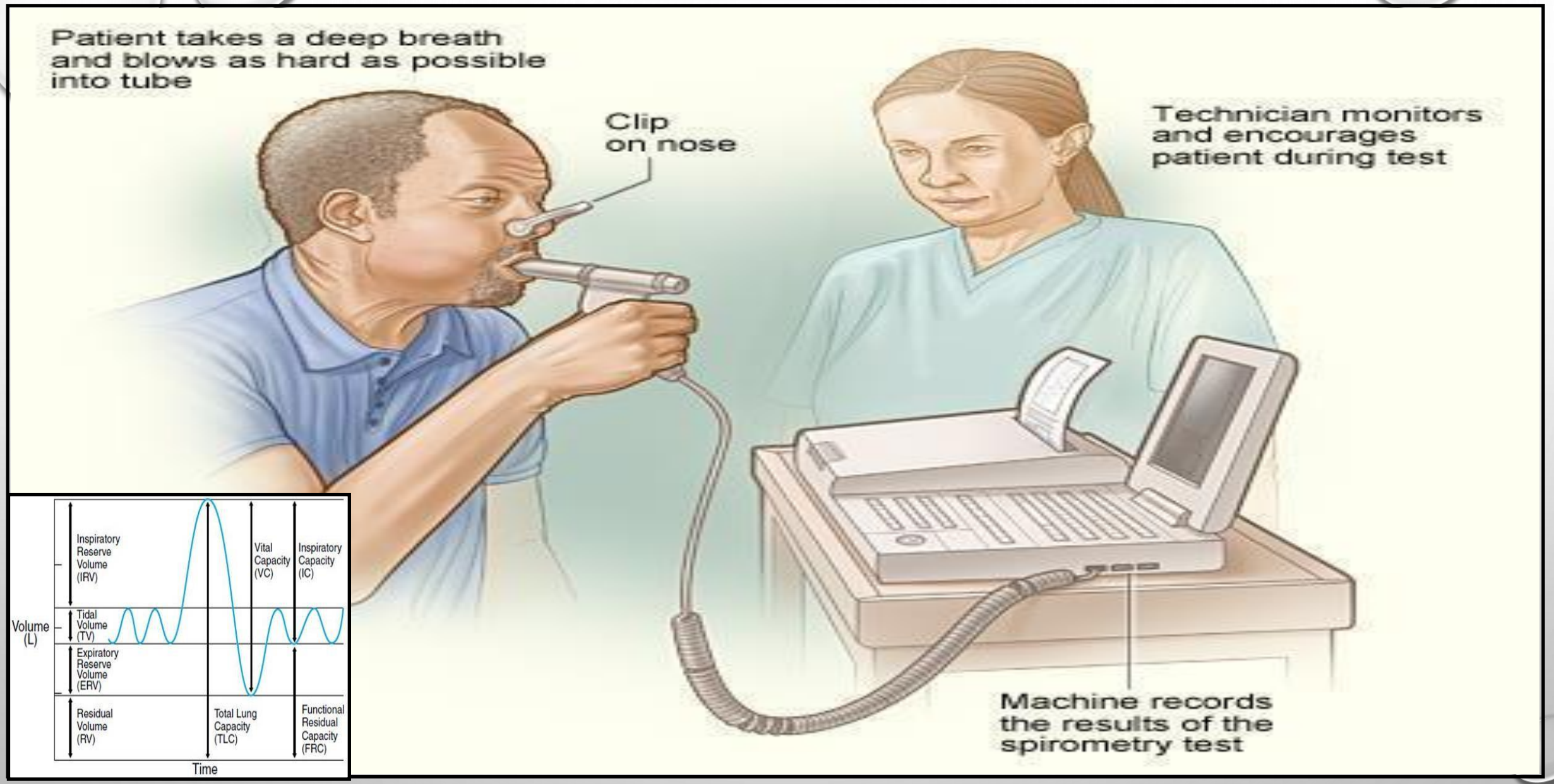
SPIROMETRY

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

Indication:

- ✓ Diagnosis of lung diseases.

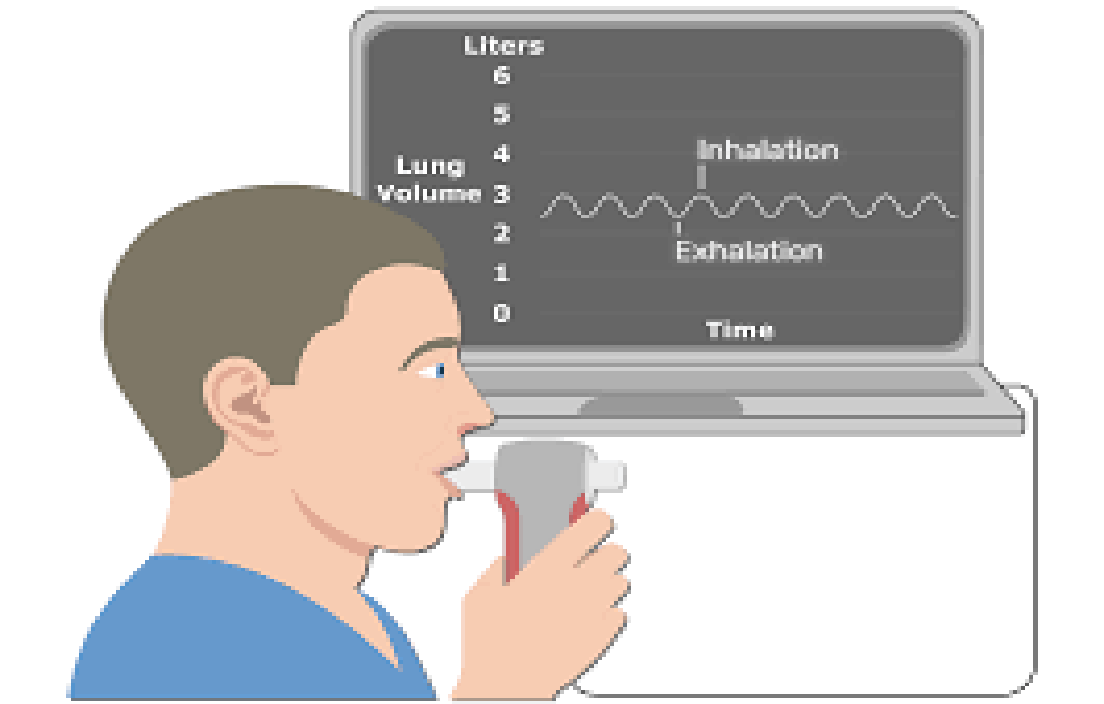
For this test, the subject breathe into a mouth piece attached to a recording device called (**spirometer**).


Patient takes a deep breath and blows as hard as possible into tube
Clip on nose
Technician monitors and encourages patient during test
Machine records the results of the spirometry test
Volume (L)
Inspiratory Reserve Volume (IRV)
Tidal Volume (TV)
Expiratory Reserve Volume (ERV)
Residual Volume (RV)
Vital Capacity (VC)
Inspiratory Capacity (IC)
Total Lung Capacity (TLC)
Functional Residual Capacity (FRC)
Time

Spirometer

SPIROMETRY
SPIROMETER
SPIROGRAM

- 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 = about 3500 ml.**

2. Functional residual capacity (FRC):

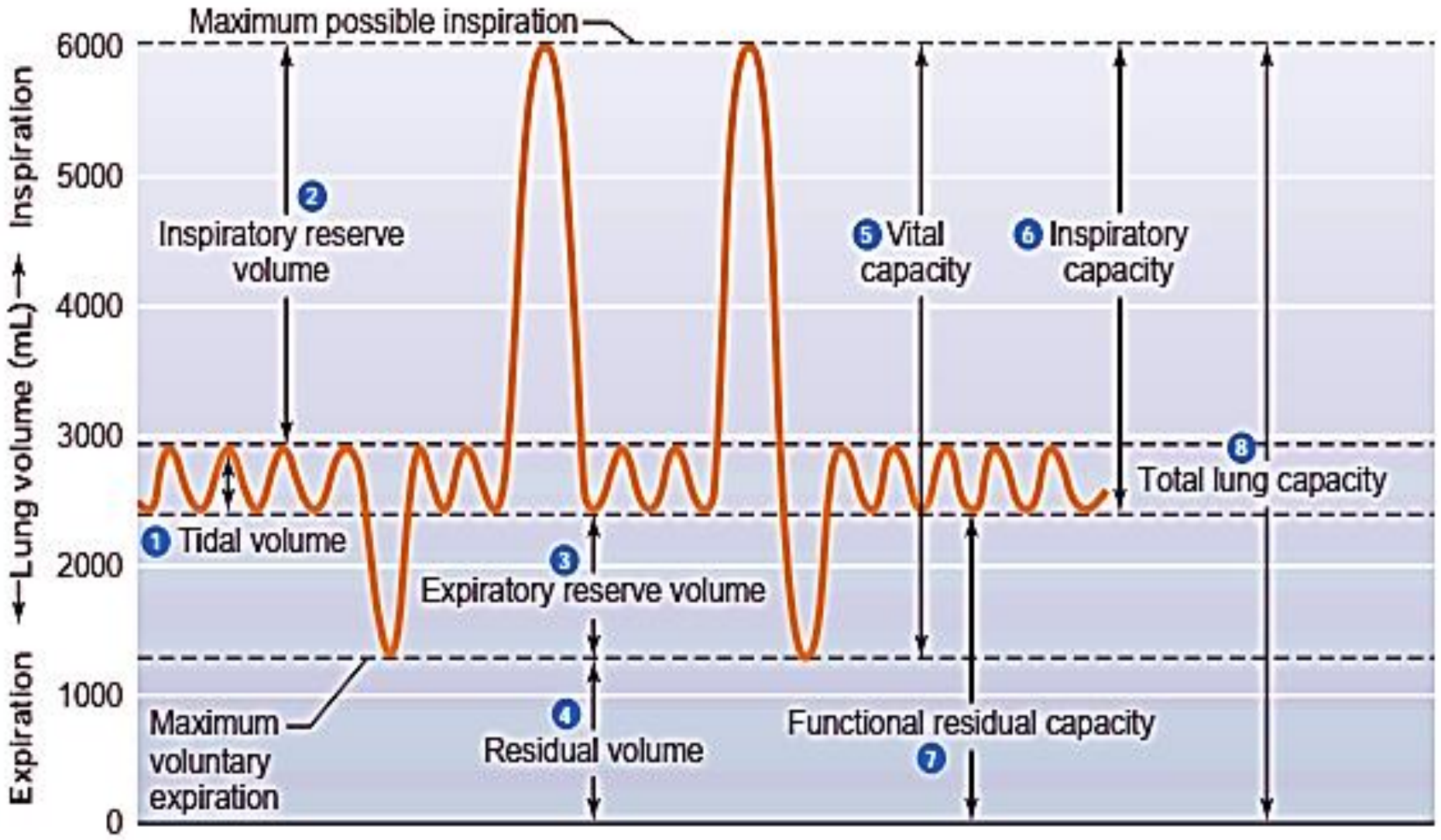
- **It's the volume of air present in the lungs after normal expiration.**
- **It equals ERV + RV = 1200 + 1200 = about 2400 ml.**
- It **can't be measured by the spirometer** as it can't measure the **RV**.

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 = about 4700 ml.**

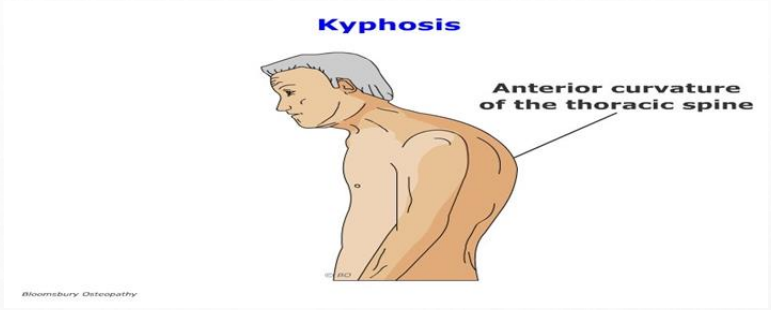
4. Total lung capacity (TLC):

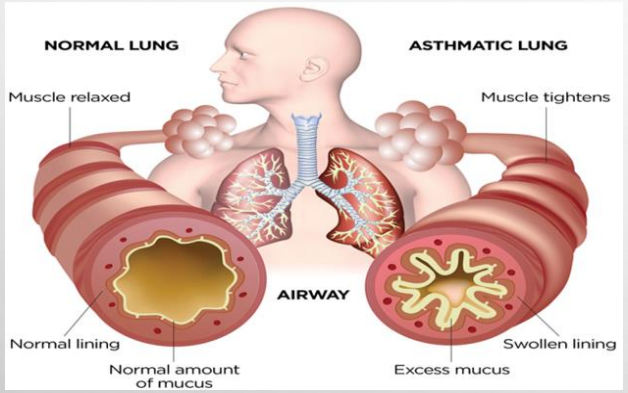
- **It's the volume of air present in the lungs after maximum deep inspiration.**
- **It includes all lung volumes (TV+IRV+ERV+RV) OR (VC + RV) = 4700 + 1200 = about 5900 ml.**
- **It can't be measured by the spirometer** (as it can't measure the **RV**).

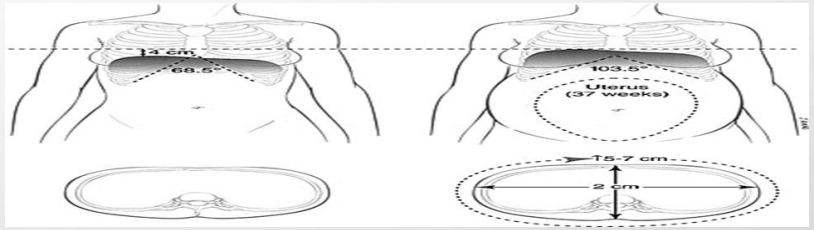

Maximum possible inspiration
6000
5000
4000
3000
2000
1000
0
Inspiration
Lung volume (mL)
Expiration
2 Inspiratory reserve volume
5 Vital capacity
6 Inspiratory capacity
8 Total lung capacity
1 Tidal volume
3 Expiratory reserve volume
Maximum voluntary expiration
4 Residual volume
Functional residual capacity
7

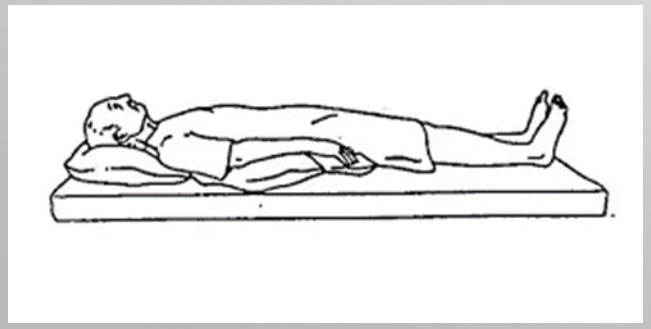
Spirogram

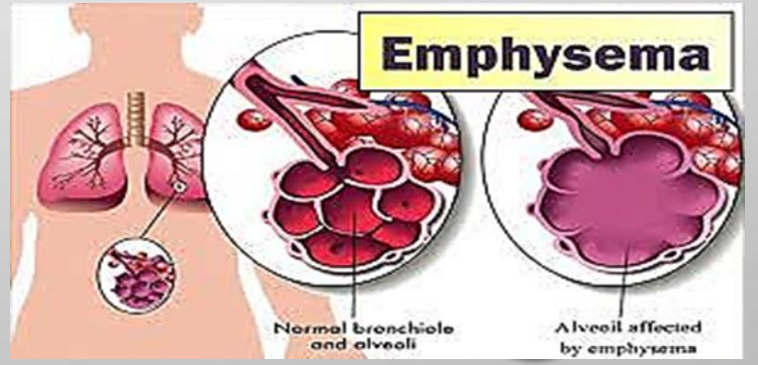
FACTORS AFFECTING VITAL CAPACITY (VC)





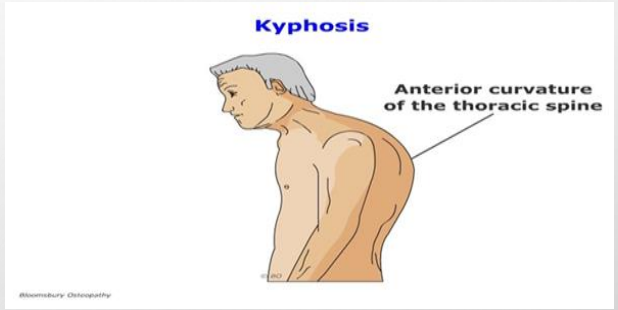




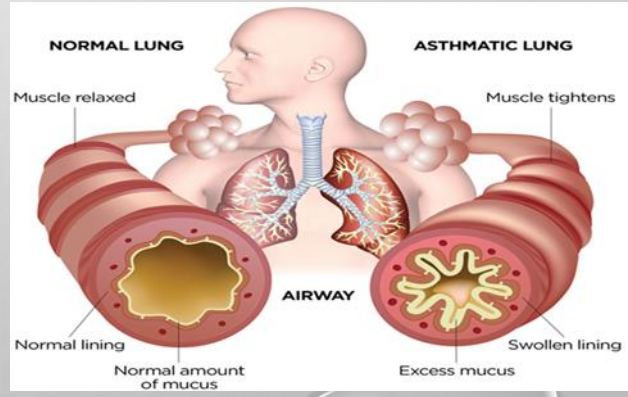


A) Muscle strength: VC is greater in **athletes** with stronger muscles than in sedentary people.

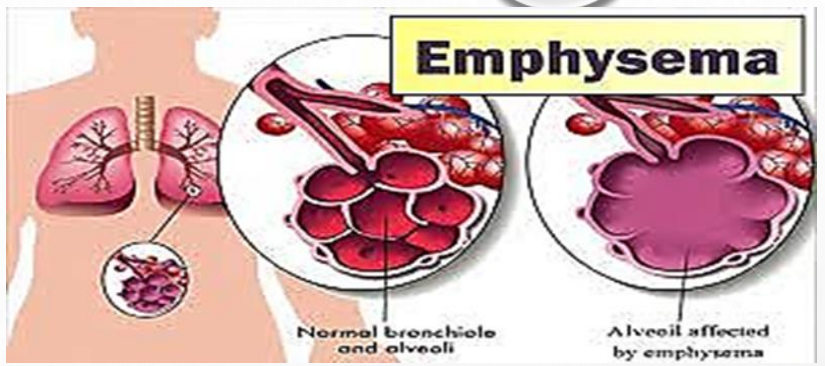
B) Mobility of chest wall and movement of diaphragm: Any deformity in the bones of the chest (**kyphosis**) or any abdominal swellings that limit diaphragm descent (as in **pregnancy or ascites**) lead to decrease in VC.



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

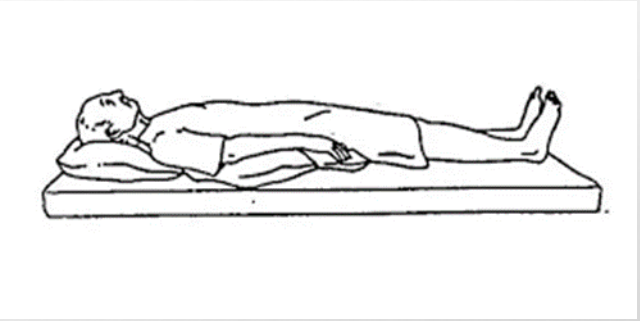


D) Elasticity of the lungs: Decreased lung elasticity also decreases VC **(as in emphysema in smokers)**.



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.

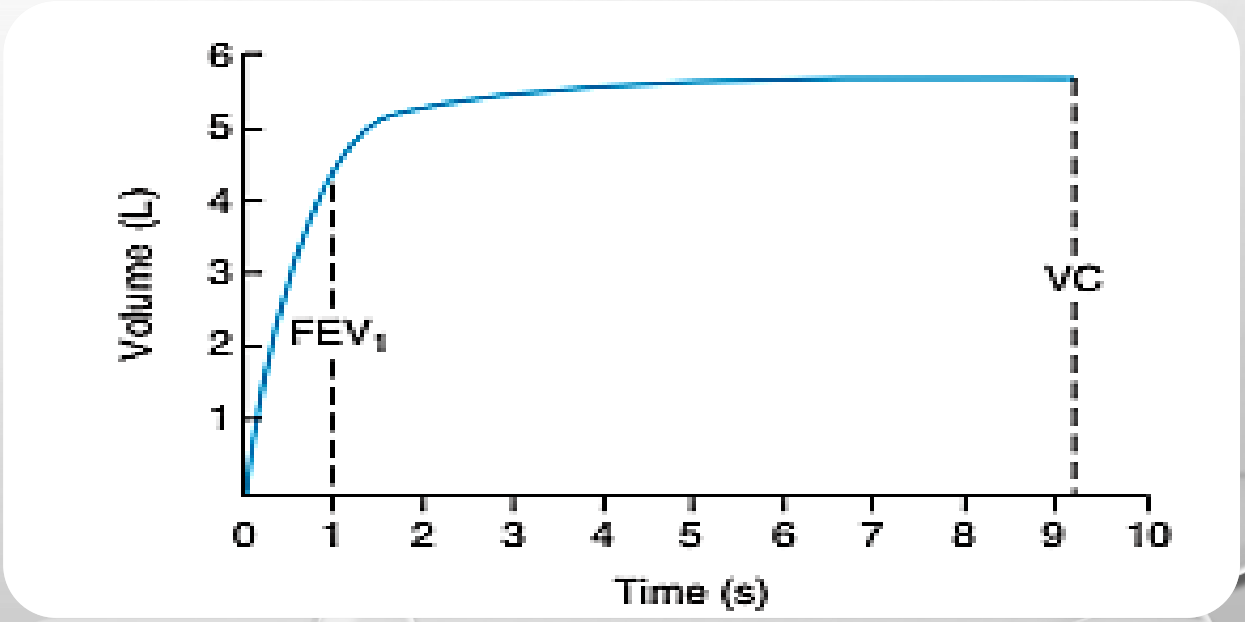
N.B.

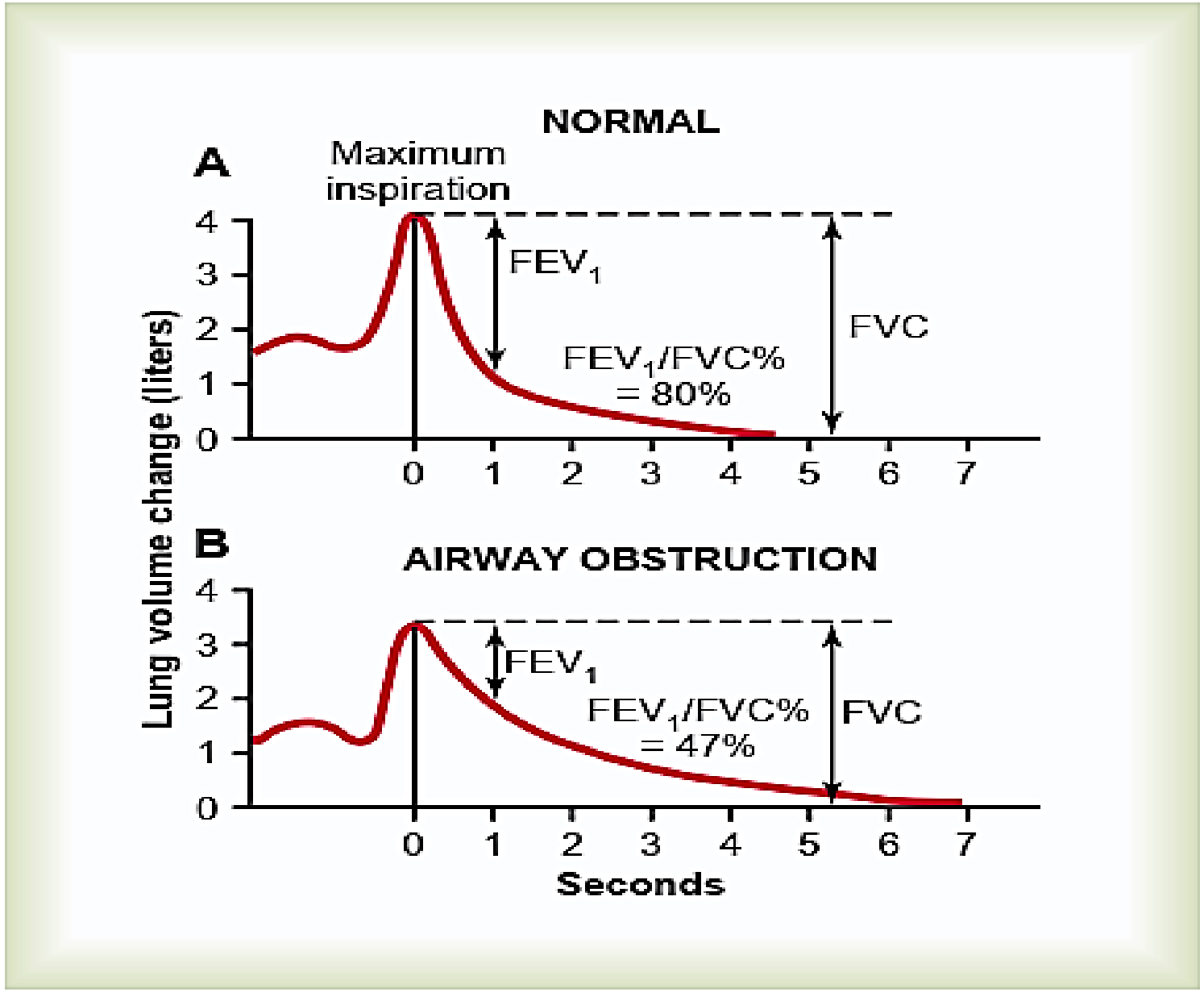
In obstructive lung diseases, (e.g. in bronchial asthma),

- ✓ **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 (FEV1) by the total VC.
- Normally about **0.8** (i.e. 80%)
- **Decreased** in **obstructive** lung diseases (e.g. **Asthma**) .




NORMAL
A
Maximum inspiration
FEV1
FVC
FEV1/FVC% = 80%
B
AIRWAY OBSTRUCTION
FEV1
FEV1/FVC% = 47%
FVC
Lung volume change (liters)
0
1
2
3
4
5
6
7
Seconds

3. Minute ventilation (V_E):

- **It is the volume of air breathed/minute.**
- = **TV x respiratory rate** = 500 x 12 = **6000 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 = **(tidal volume - dead space) x respiratory rate**.

  = (500-150) x 12 = 350 x 12 = **4200 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 X 24 = 6000 ml/minute (i.e. Normal), while alveolar ventilation will be; (250-150) x 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 → excessive wash of CO_2 →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) =**

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

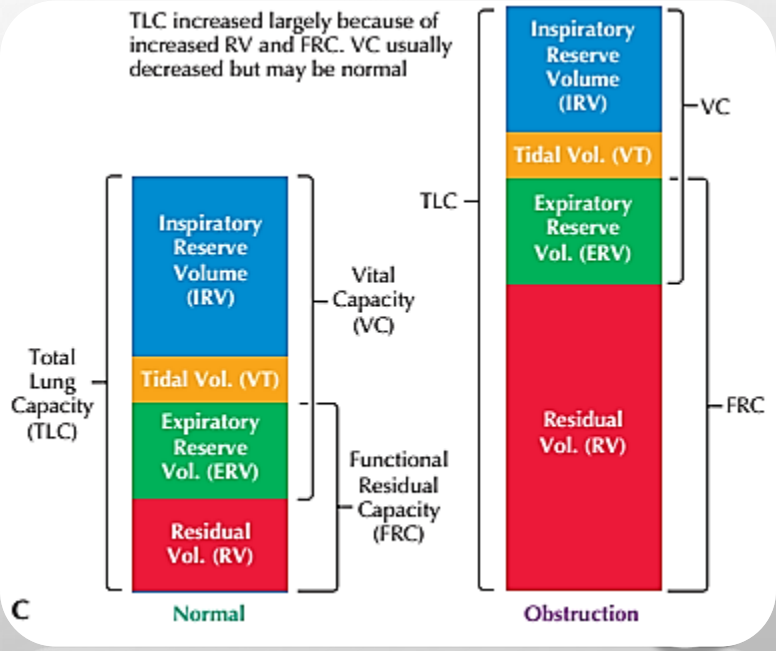
- Normally, **DI** is about **90 %**.
- when D.I. < 70 %, dyspnea occurs on slight effort.

RECALL INFORMATION

Obstructive lung diseases:

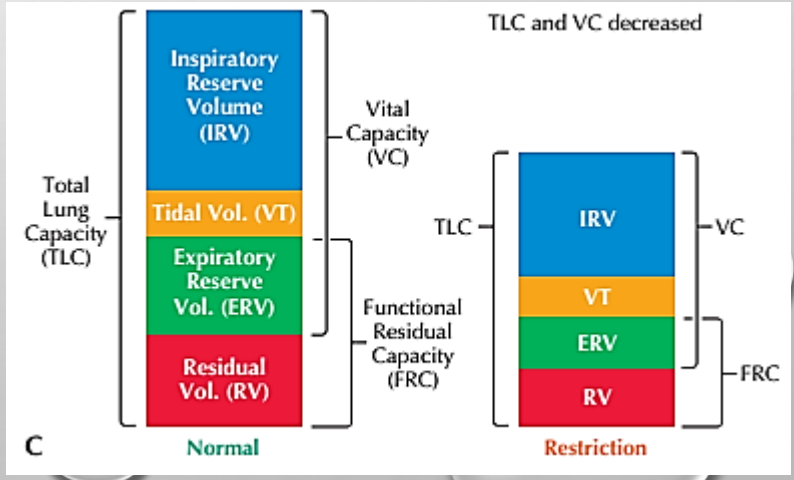
- Also, they are referred to as chronic obstructive pulmonary diseases or COPD (e.g. Emphysema and chronic bronchitis) and asthma.
- These diseases are characterized by **air outflow obstruction (with/without inflow obstruction)** and subsequent **air trapping within the lungs**.
- Pulmonary function 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.**

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