Lung Volumes & Capacities

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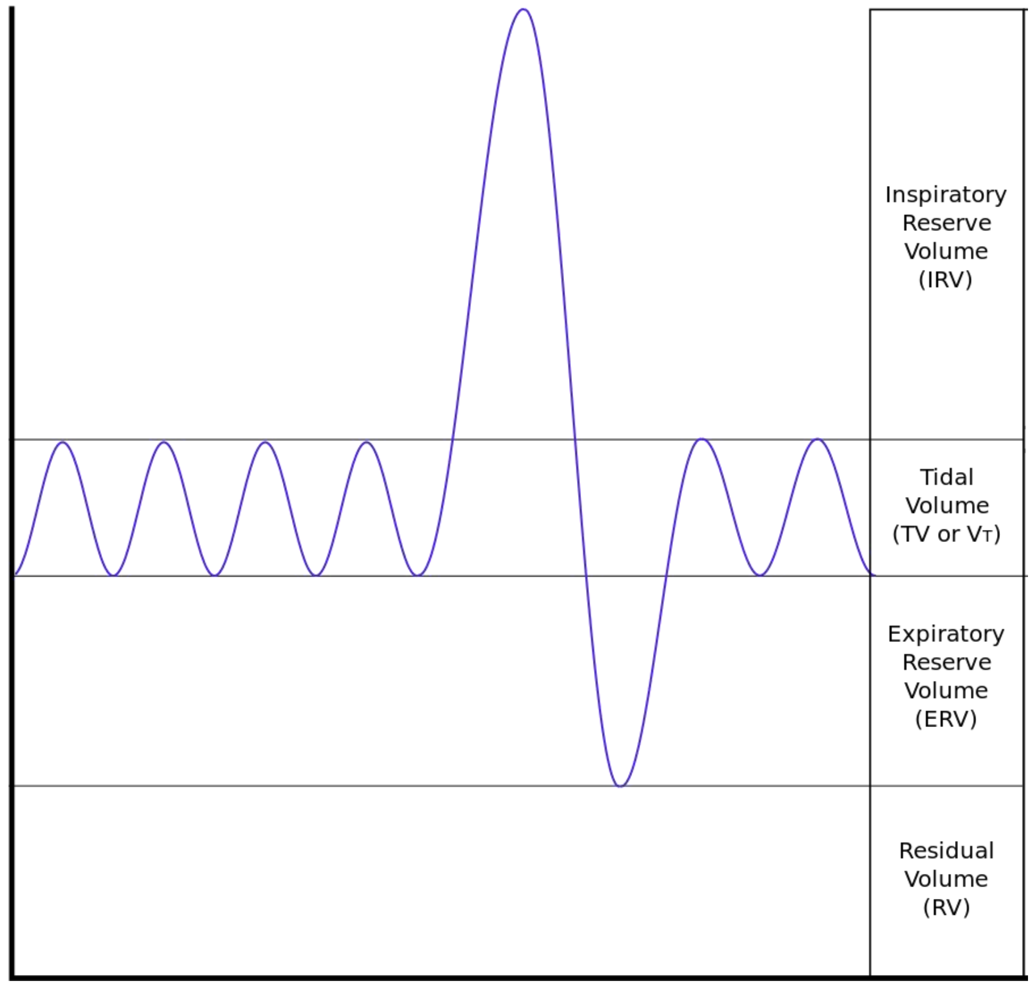
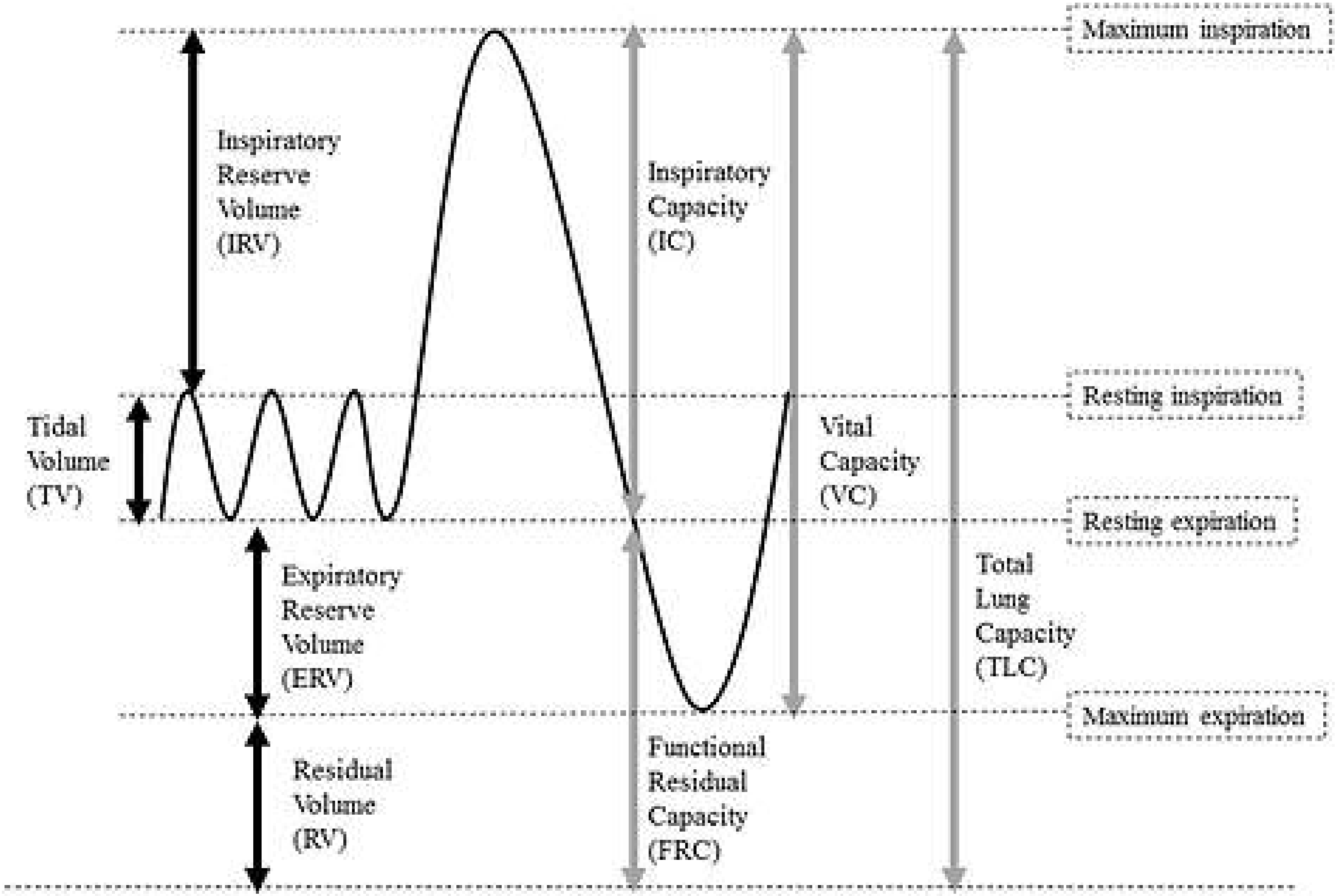
Lung volumes

- **Tidal volume (TV) = 500 ml**
  Vol. of air inspired or expired with each normal breath of normal quiet breathing(**eupnea**)
- **Inspiratory reserve volume (IRV) = 3000 ml**
  Vol. of air which can be inspired by **maximum forced inspiration** ***AFTER*** normal inspiration.
- **Expiratory reserve volume (ERV) = 1100 ml**
  Vol. of air which can be expired by **maximum expiration** ***AFTER*** normal expiration.
- **Residual volume (RV) = 1200 ml**
  Vol. of air remaining in the lung after maximal expiration.
  Can't be tested by spirometry.



Lung capacities



1- Inspiratory capacity (IC):

- It is the volume of air that can be inspired by maximal inspiratory effort ***After*** the end of normal resting expiration
- IC = TV + IRV = 500 + 3000 = 3500 ml.

2- Expiratory capacity (EC):

- It is the volume of air that can be expired by maximal expiratory effort ***After*** the end of normal resting inspiration
- EC = TV+ERV =500+ 1100 =1600 ml.

3- Functional residual capacity (FRC):

- It is volume of air remaining in lungs after normal expiration.
- FRC = ERV + RV = 1100 + 1200 = 2300 ml.

Can't be tested by spirometry.

4- Vital capacity (VC):

- Volume of air expired maximally after maximal inspiration.
- VC= IRV + TV + ERV = 3000 + 500 + 1100 = 4600 ml.

5- Total lung capacity (TLC):

- Volume of air present in the lung at end of maximal inspiration.
- TLC = VC + RV = 4600 + 1200 = 5800 ml

Can't be tested by spirometry.

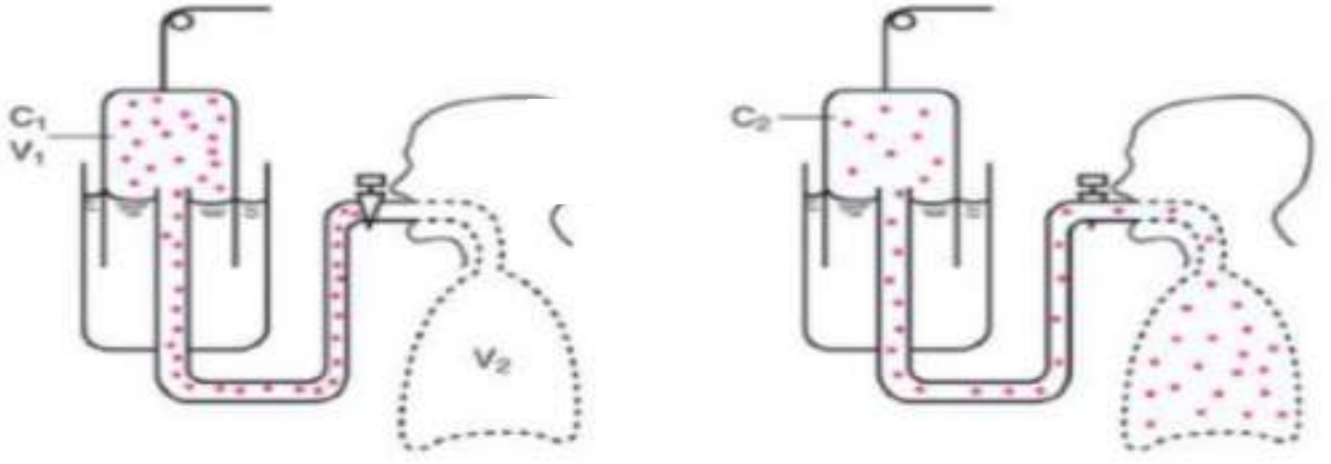
Static pulmonary function tests

1. Residual volume:

Measured by **Helium dilution method**, using the dilution principle

$$C1 \times V1 = C2 \times V2$$

Helium is used as an inert gas & not diffuse to blood from alveolar air



Before equilibration

After equilibration

Importance of Residual volume

1) Provides air in alveoli to oxygenate the blood between breaths

2) Prevents lung collapse & Keeps the lung distended

3) Prevents marked changes in PO_2 & PCO_2 in the blood with each respiration

4) Prevents marked changes in inspired air temperature & humidity

5) RV / TLC Less than 30% (increase in **bronchial asthma** & **emphysema** due to **insufficient expiration**)

6) Medico legal importance

It determines cause of death of baby after birth

If baby is born alive, he will respire, so contain RV → lung float in water while If baby is born dead, he will not respire, so no RV → lung sink in water

Minimal air: Few air remain in lung even after lung collapse

(150 ml)

2. Total lung capacity (TLC)

- **Definition:** the volume of air present in the lung at the end of maximal inspiration
- **Measurement:**

TLC = IRV + TV + ERV + RV

TLC = VC + RV

Normal value: 5800 ml

- **Significance:**

Decreases in pneumothorax

3. Vital capacity (VC)

Definition: It is the amount of air expired maximally after maximal inspiration

Measurement: by spirometer

Value: VC = IRV + TV + ERV = **4600 ml**

Significance:

It indicates the strength of respiratory muscles and lung elasticity

Factors affecting Vital Capacity

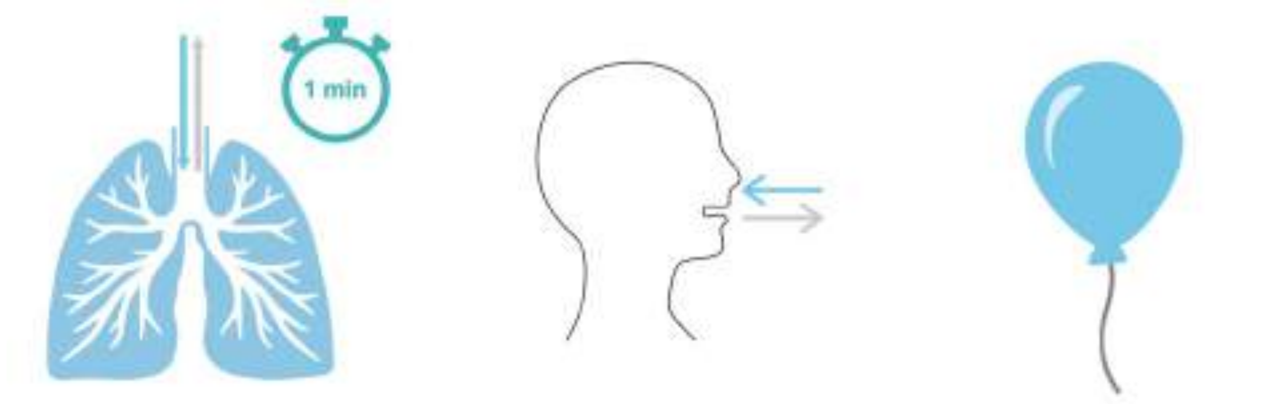
	Increase	Decrease
Physiological	Athletes	Females, old age, pregnancy and recumbent position due to return of more blood to the lung.
Pathological		a- **Chest wall diseases**: - Paralysis of respiratory muscles &myasthenia gravis - Fracture ribs or kyphosis(limit expansion of thorax) b- **Lung diseases**: -Decreased compliance (stretchability) **as(fibrosis, hydrothorax, pneumothorax**) -Decreased elasticity as (**emphysema**) - Obstructive conditions like **bronchial asthma** as resistance to air flow <u>mainly during expiration</u> c- **Increased blood volume in the lung**: as in pulmonary congestion by left side heart failure. d- **Presence of intra-abdominal masses**: as tumour and ascites. So, prevent free descent of diaphragm.

Dynamic pulmonary function tests

❖ **Respiratory minute volume (RMV) (Minute ventilation):**

It is the volume of air respired/min.

At rest = TV x respiratory rate = 0.5 x 12 = 6 L/min.



Minute ventilation = respiratory rate (RR) × tidal volume (V_T)

Dead space (DS)

- **Def.**: Volume of air which does not undergo gas exchange in respiratory system
- **Types**:

1. **Anatomical DS**: thick respiratory passages (from nose to terminal bronchioles).

2. **Alveolar DS**: non functioning alveoli (normally absent)

3. **Physiological DS**: = anatomical + alveolar DS.

Normally, DS = anatomical = **150 ml**

N.B.: Inspiration through a tube → **increases DS**

Significance of dead space

1) Protective functions

2) Prevents marked changes in **PO_2** & **PCO_2** in the blood with each respiration.

3) Prevents marked changes in inspired air temperature & humidity.

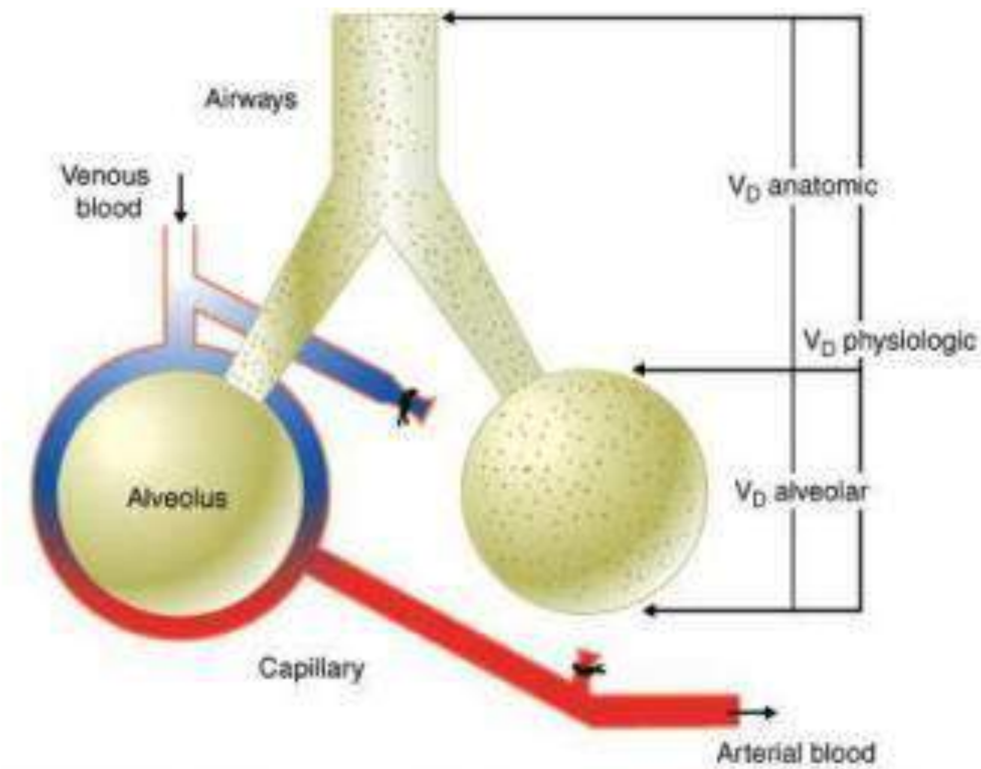
4) It is responsible for difference between Respiratory minute volume **(RMV)** & Effective ventilation volume **(EVV)**

❖ Effective ventilation volume (EVV):

It is the volume of air that enters in gas exchange/ min.

At rest = (TV – DS) x respiratory rate = 0.35 x 12 = 4.2 L/min.

Dead space



- **Maximum breathing capacity (MBC) or maximum voluntary ventilation:**

  Maximal volume of air that can be inspired or expired using the deepest and fastest respiratory movements.

  Measured in 15 seconds then multiplied by 4.

  MBC= 80 to160 L/min in **males**, 60 to120 L/min in **females.**

❖ Breathing reserve:

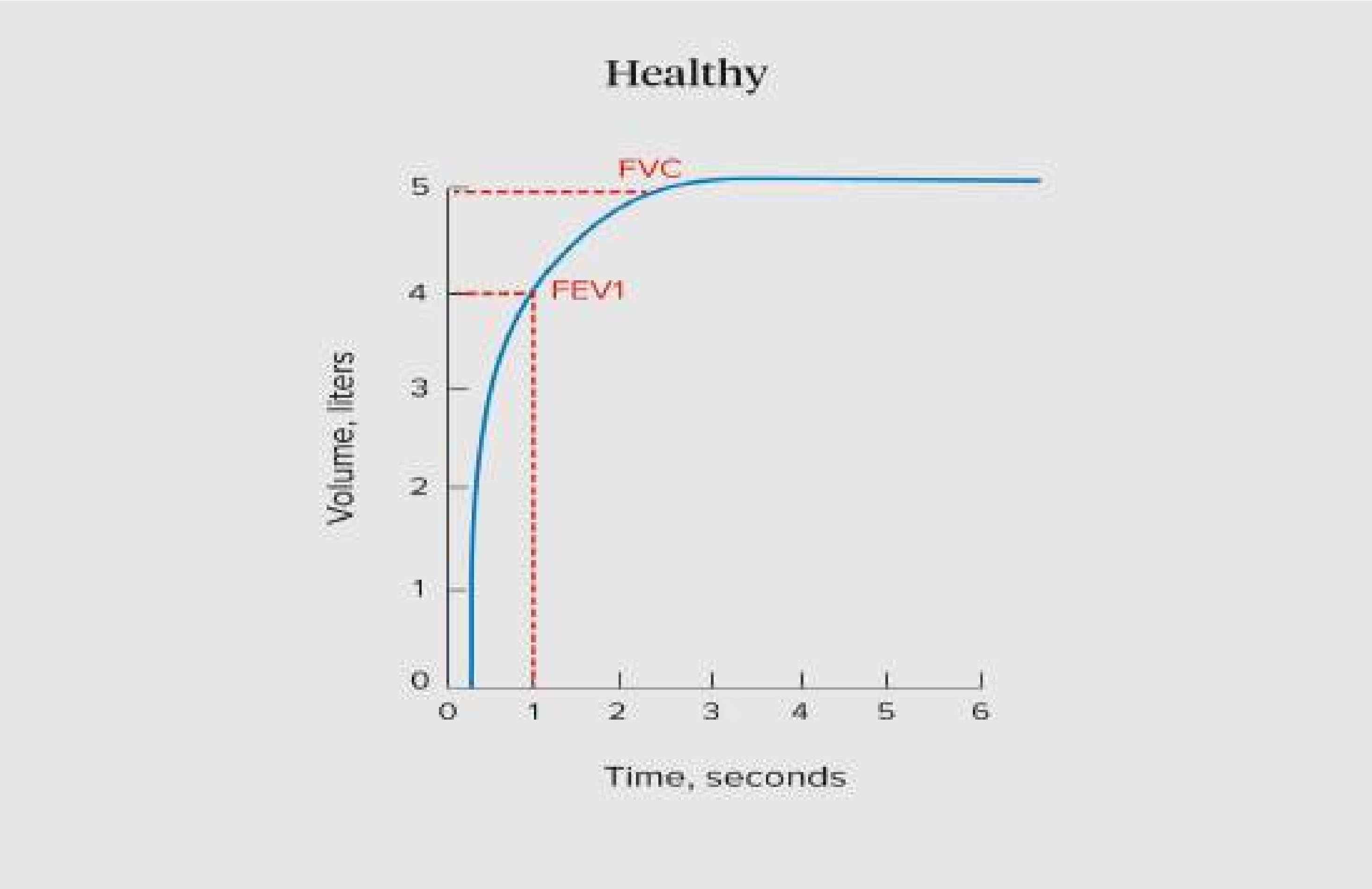
- The ***difference*** between the MBC and RMV
- BR = 100 – 6 = 94 L.

❖ Dyspneic index (DI):

- The ***percentage*** between the **breathing reserve** and the **MBC**.
- Normally DI > 90%
- If DI < 70% Dyspnea

❖ Timed vital capacity:

- **FEV1:** The fraction of vital capacity expired maximally and rapidly in the first second. **FEV1= 83% of VC**, and reaches **97% in three seconds** (good test for airway resistance so, it is helpful in **obstructive lung diseases** diagnosis & prognosis (e.g. asthma & emphysema)



Healthy
FVC
FEV1
5
4
3
2
1
0
0
1
2
3
4
5
6
Volume, liters
Time, seconds

Obstructive lung disease

- **E.g. Asthma & Emphysema**
- VC decreased
- FEV1 decreased markedly
- FEV1/ VC is reduced
- TLC is almost normal
- RV is increased

Restrictive lung diseases

- **E.g. Lung fibrosis**
- VC is decreased
- FEV1 is decreased
- FEV1/ VC *may be normal*

As both decreased equally

- TLC reduced

THANK YOU