Lung Volumes & Capacities

By

Dr.Nour A.Mohammed

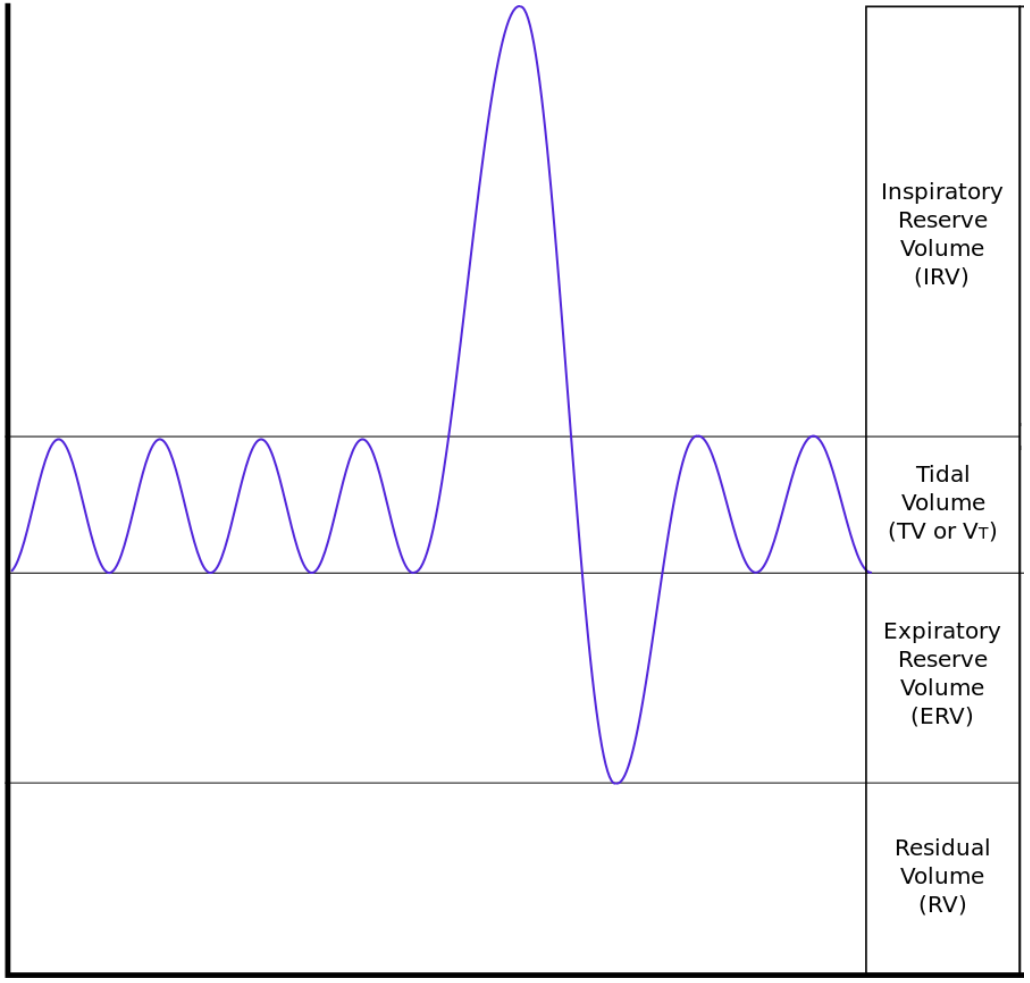
Associate professor of physiology

Faculty of medicine,Mutah University

- -Normal breathing --→ eupnea
- -increase rate of breathing ---→ tachypnea
- -decrease rate of breathing --→ bradypnea
- -stop breathing ---→ apnea
- -diffucult breathing ---→ dyspnea

Lung volumes

- **Tidal volume (TV) = 500 ml**
  Vol. of air inspired or expired per each cycle 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.



- *The 3000 volume of air are mesured after tidal volume , means that the total inspired volume of air at the end of IRV are 3500 =500 +3000 ml
-
- *After = in addition to
-
- *residual volume (RV) can’t be exert from lung , except if lung collapsed , when you open chest .
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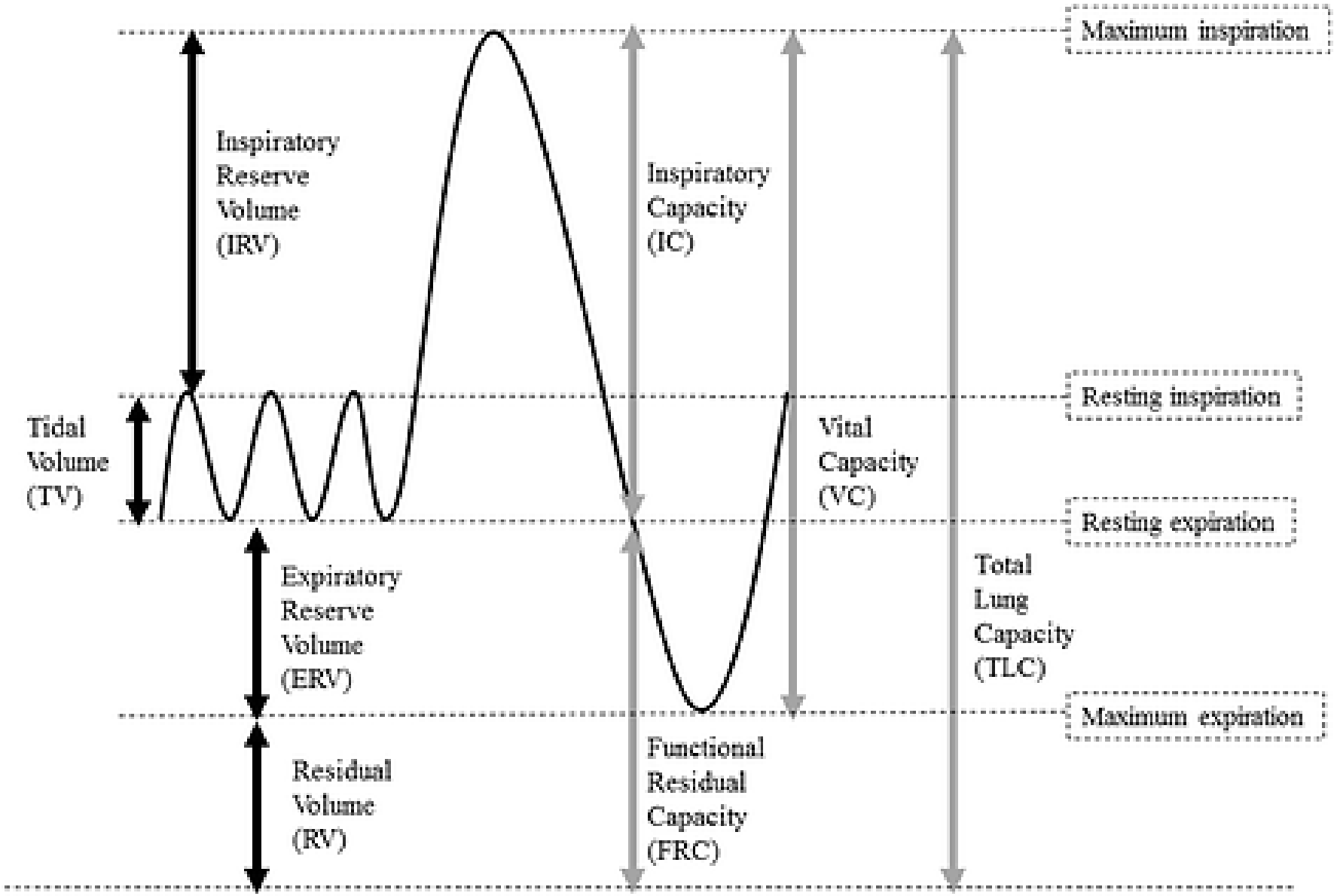
- *spirometry depend on closing of nose and respiration by mouth by certain technique

Lung capacities

Capacity→ more than one volume added to each other



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.

- -Vital capacity has clinical valye and very important for mesuring
-
- -Any capacity that involve in its calculation RV you can’t calculate it directly by spirometry , you have to calculate another volumes and then measure it by another method then add it mathematically

Static pulmonary function tests

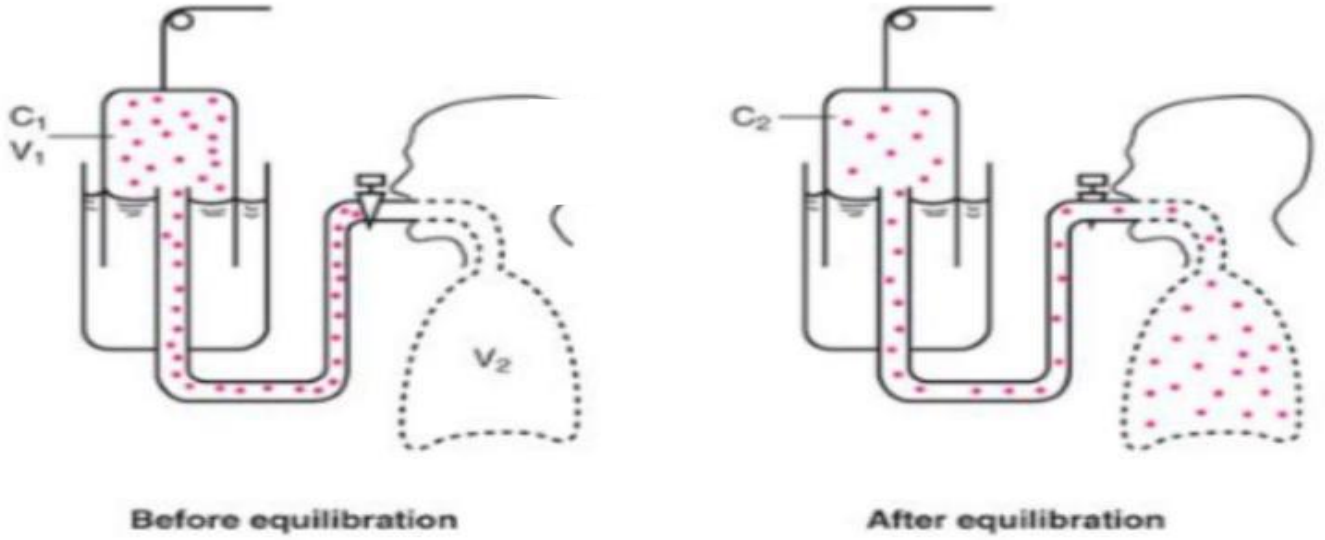
Static -→ p emti ot detaler toN .1
.2Mesured by certain position known as medthoracic position

1. Residual volume:

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

C1 x V1 = C2 x V2

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



The mechanism of static pulmonary function test

الدكتورة قالت مش مهم تعرفوا تفاصيله بس هي التبييض للي بده يدرسها

- *RV doesn’t exert from lung , except in lung collapse , and by the way it doesn’t exert totally , there are 150 ml well remain.
-
- *we use closed container) closed circuit (دارة
-
- *we use indicator , this indicator are helium , why ??
-
- .1It is inert
- .2Don’t produced or utilized by the body -----→ the value of it will remain constant .
- .3Can’t cross pulmonary wall and enter capillary wall.

- *Vreniatnoc ni utp uoy emulov →----1
- *C muileh fo (notiartnecnoc) ssam emulov →----1
-
- ---
- *you till patient to make forced expiration , this will lead to remaining of residual volume in lung only .
- -the nose of patient will be closed by nose clap , and you will open the valve , then patint will respire by mouth for ( ) semti (6 –4 too & through (او ما فهمتها بالضبط
-
- *this proccess will continue to reach equilibrium , then helium concentration will diffuse in equilibrium .
-
- ---
- Then V2 C &2 will formed .
-
- *V VR +1 V →------2
- *C fo gnisolc & notiaripser refta muileh fo notiartnecnoc →------2) emulov wen n reniatnoc ni notiubirtsid ti refta (evlav

- *N.B : the amount of helium are not change , because body wil not produce or utilize it , and it is inert & not cross alveolar wall .
-
- *N.B : you don’t exert RV , but you calculate it

Importance of Residual volume

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

In pause , or in between respirations

2) Prevents lung collapse & Keeps the lung distended

This will increase work of breathing if lung will collapse after each breath & then start from collapsing

3) Prevents marked changes in PO2 & PCO2 in the blood with each respiration

Because you get it from RV the PO2 OCP &2 will not suddenly change.

4) Prevents marked changes in inspired air temperature & humidity

RV ---→ make conditioning of air

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

-important clinically.

-if ratio increase , this indicate that are problem in expiratory process] appear in obstructice pulmonary diseases as asthma & emphysema]

Next slide .....

Asthma

- -Asthma are allergic reaction for certain antigens that make IgE antibodies , then in next expouser to antigen , antigen –antibody reaction between antigen & IgE on the membrane if mast cell , that lead to secreation of allergy mediators as histamine.
-
- -attacks in asthma are at late night & early morning , because it related to circadian rhythm (توقيت الساعة البيولوجية) of ANS , because highest tone of parasympathatic , parasympathatic will be very high and has the upper hand , parasympathatic will cause bronchoconstriction , increase secrration & vasodilataion , this will lead to decrease of respiratory level

Emphysema

- -Emphysema are degenerated disease mainly in elastic fibers in lungs .
-
- Most common cause of it are heavy seggurate smoking , because of two things :
-
- .1Smoking will increase macrophages in alveoli , macrophage will secret mediators , mediators will call leukocytes (WBCs) , leukocytes will secret another mediators , one of them are elastase enzyme which will destruct elastic elements in lungs .
-
- .2Smoking will increase O2 radicals , that will inhibit Cl- antitrypsin , which are stop elastase .
-)Cl- antitrypsin function are to stop work of elastase , but O2 radicals will inhibit Cl- antitrypsin(

Obstructive pulmonary disease

- In obstructive pulmonary disease , there are problems in ispiration , but the main problem are in expiration , because in during inspiration the lung make resistance for air flow , but during expiration lung will make diflation , (اظن هيك هي) so also onstructed bronchioles make more compression , so resistance will increase to very high level.

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

-When you open chest , the RV will loss , and the lung will collapse , except 150 ml will remain , known as minimal air.

-if minimal air are not found , that mean the baby has not take any breath from bearth , that means it will be died befor labor ..... But if you find the air , that mean baby was take breath then it die.

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

-TLC (Total Lung Capacity) are important in restrictive lung diseases (diseases which interfere with lung distention)

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 mainly during expiration 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.

Notes about factors affecting vital capacity

- **Physiological factors :
-
- -female : copmared to male with same age group
-
- -pregnancy : it will interfer with diaphragmatic movement , so decrease vital capacity .
-
- ***pathological :
-
- -lung disease which will decrase compliance are known as obstructive lung disease .
-
- -increasing in blood return to the lungs may be physiological in ..... Or pathological in left heart faliure , in which the heart can't pump blood from left ventricle to aorta , so blood will return to Lt .Atrium , then return to 4 pulmonary veins , then return to lungs.

Dynamic pulmonary function tests

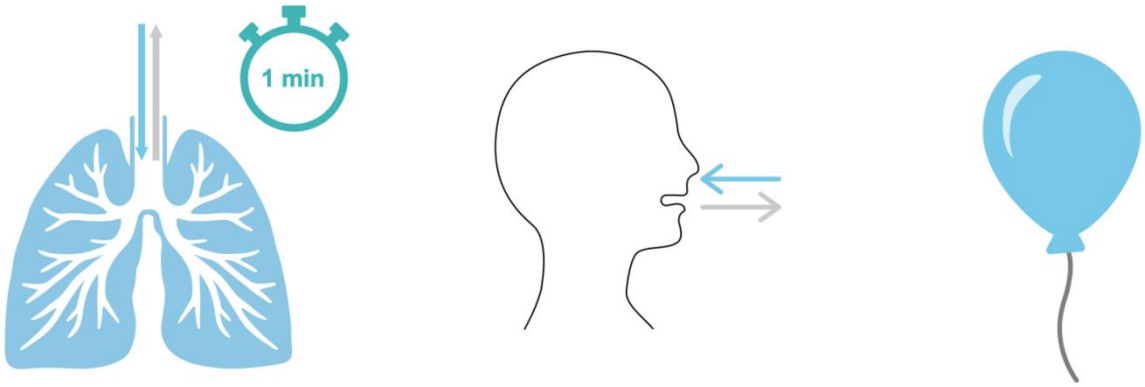
Dynamic because time factor wil be involved

❖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.

RMV are not involve totally in gas exchange process , so we calculate effective ventilation volume (EVV)



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

Air may reach alveoli and don't make gas changes , this will occur when its blood vessel are obstructed .....This space or condition are not found normally.

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 **PO2** & **PCO2** in the blood with each respiration.

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

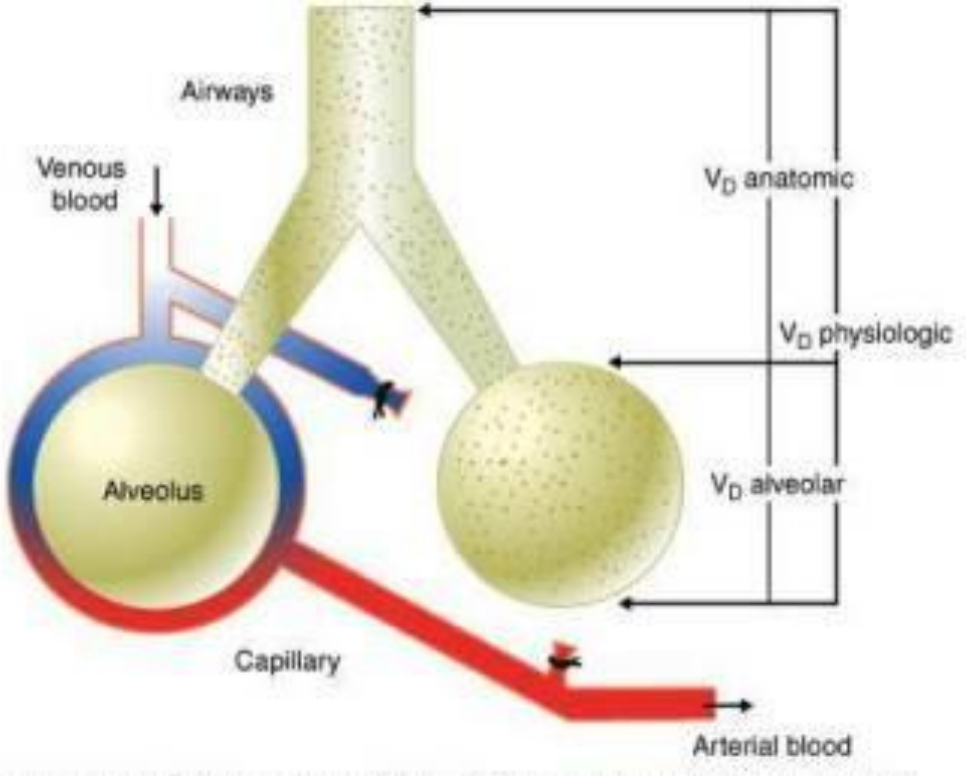
4) It is responsible for difference between Respiratory minute volume **(RMV)** & Effective ventilation volume **(EVV)**

❖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.

-it is a reserve of air for you .

-differ from person to another dependent on respiratory muscle power , so males MBC are higher than females.

Measured in 15 seconds then multiplied by 4.

Because :

.1it will make wash of CO ni etatepecerp lliw taht , sisolakla ot dael taht ,2 (-lC) level muiclac dezinoi esaerced ot eud yantet

.2CO2 are the main stimulant of respiration .

N.B : the main function of RS are to exert CO 2O ekat ot ton (noitaripxe)2 !!!

You may handle hypoxia , but you can't handle increasing in CO2

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

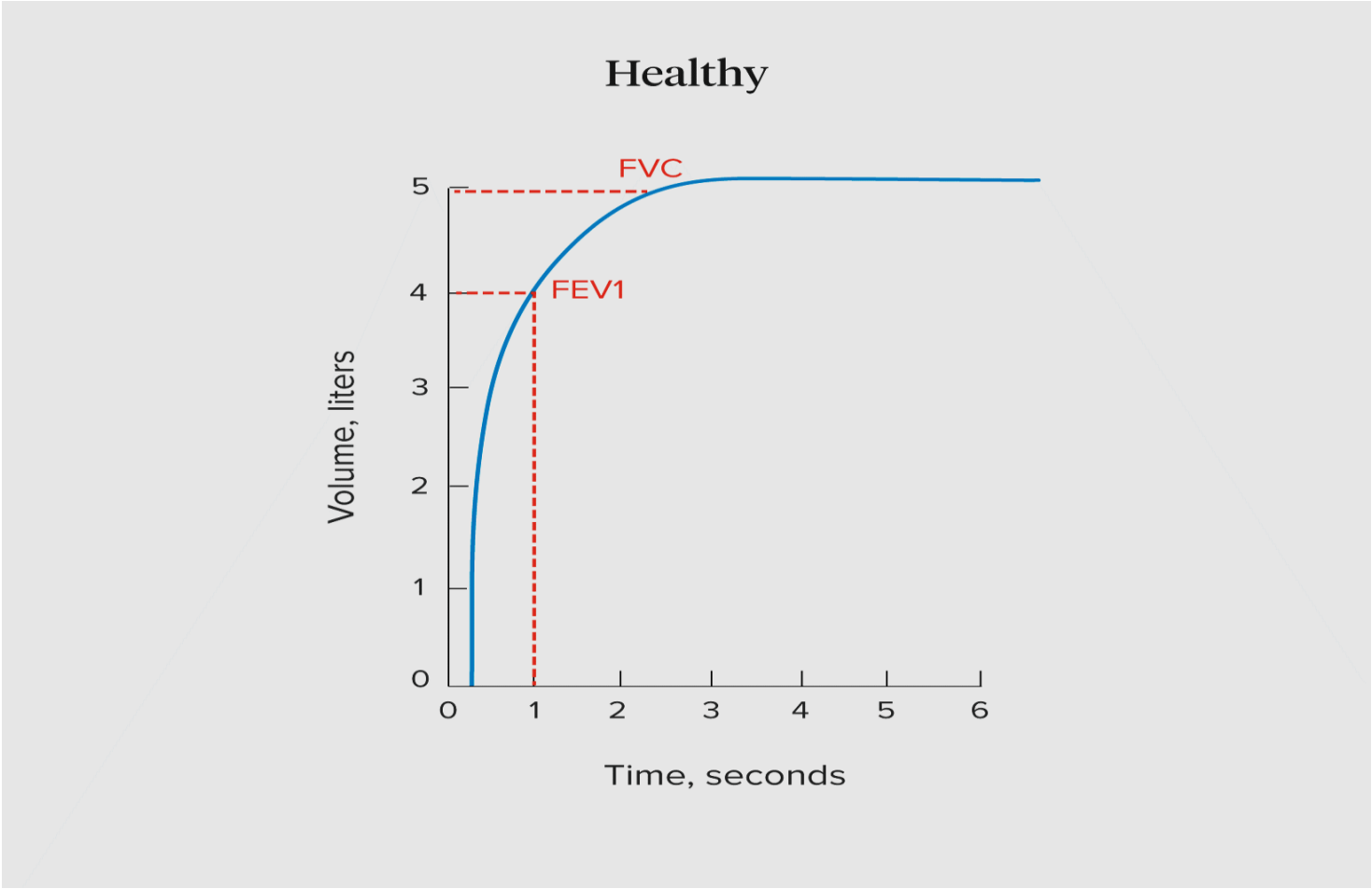
-Breathing reserve : the amount of air you can increase above thr TRC .

-Dyspnea : known also as awarnes off breath , because respiration will be done subconsciously.

❖ 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)

- - FEV1 : it is the forced expiratory volume of the 1st second .
  - the normal are VC (vital capacity) will expired in forced expiration in 4-6 seconds
  في الوضع الطبيعي بيطلع بعد ٤ - ٦ ثواني ، احنا في هذا الاختبار شفنا قديش حجم vital volume يعني انه ال الهواء اللي طلع بعد أول ثانية
  -we use this test to diffrentiate between obstructive lund disease and restrictice lund disease , but we use it mainly for obstructive lung disease .


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

- -Restrictive lung disease : diseases which interfere with lung expantion .
-
- -spirometry will mesure fracture FEV . CV /1
-
- -iñ the first you make TLC test , if it normal the disease are obstructive , if it reduced thr disease are restrictive , then you will continue in examination & treatment.

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.