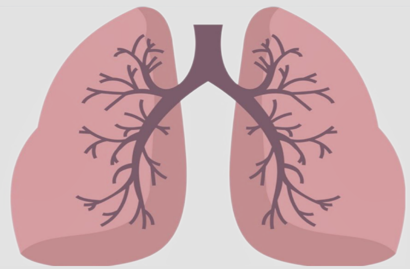
Respiratory Ventilation



Respiratory Block

Physiology 439 team work

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MED439

Editing file

@Physiology_439

- Black: in male / female slides
- Red : important
- Pink: in female slides only
- Blue: in male slides only
- Green: notes
- Gray: extra information
- Textbook: Guyton + Linda

Objectives :

01 Define the various Lung Volumes and capacities and provide typical values for each..

02 Define ventilation rate, their typical values, and their measurement.

03 Describe FEV1 and its role in differentiating obstructive and restrictive lung diseases.

04 Describe the types of dead space. State a volume for the anatomical dead space.

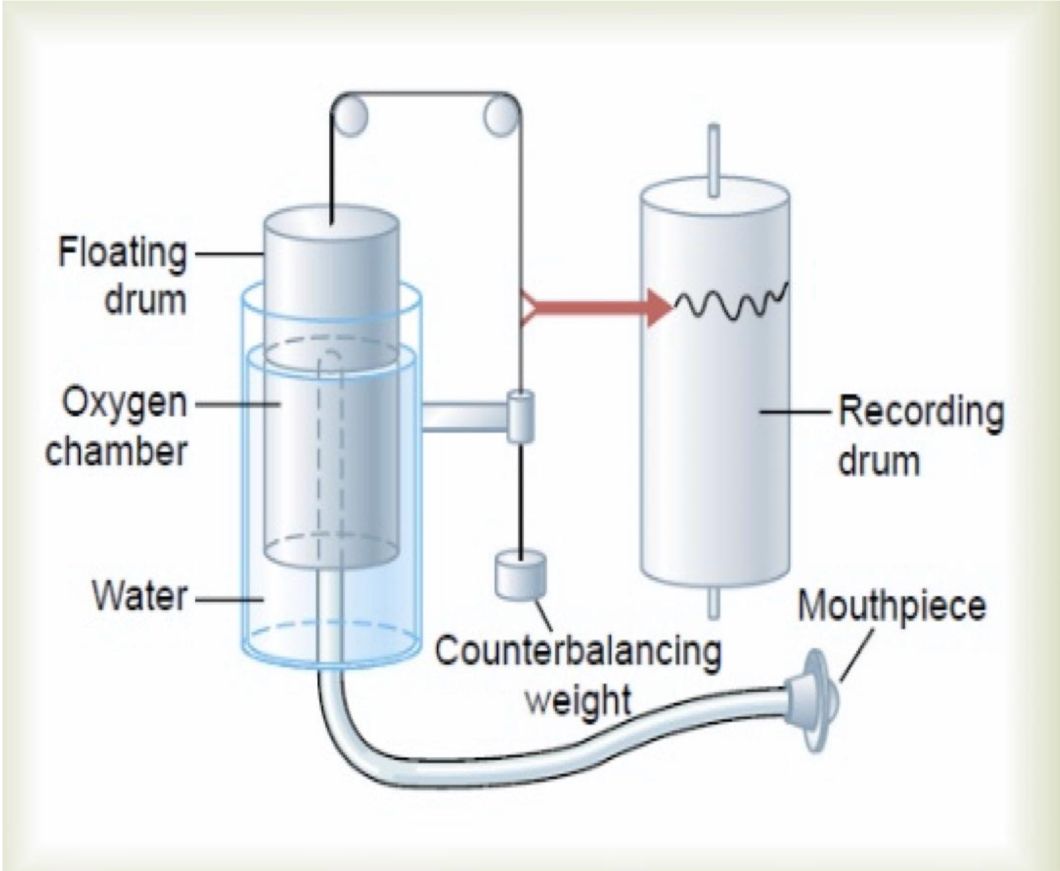
05 Define the term minute ventilation and state a typical value.

06 Distinguish minute ventilation from alveolar ventilation.

Spirometer: EXTRA INFO

From Guyton:

The spirometer consists of a drum inverted over a chamber of water, with the drum counterbalanced by a weight. In the drum is a breathing gas, usually air or oxygen;a tube connects the mouth with the gas chamber. When one breathes into and out of the chamber, the drum rises and falls, and an appropriate recording is made on a moving sheet of paper.



Pulmonary volumes:

lung volumes and capacities (by using spirometer):

4 lung volume:

Tidal volume (TV): normal breathing
is the volume of air inspired or expired with each normal breath = **500ml**.
TV=Vd"anatomical dead space"150 + Va"participate in gas exchange"
حركته زي المد والجزر

Inspiratory reserve volume (IRV): deep inspiration
is the extra volume "Maximal" of air that can be inspired over and above the tidal volume (inspiration with full force) = **3000ml**.

Expiratory reserve volume (ERV): deep expiration
is the extra amount "Maximal" of air that can be expired by forceful expiration after the end of a normal tidal expiration = **1100ml**.

Residual volume (RV) "can't be measured by spirometer":
is the volume of air that still remain in the lungs after the most forceful expiration = **1200ml**. (after forced expiration , some air will stay to prevent the lung collapsing,
Maintaining gas exchange in between breathing, and preventing marked changes in PCO2 and O2 in the blood in between breathes.(what we call buffering marked changes in the blood gasses from breath to breath)

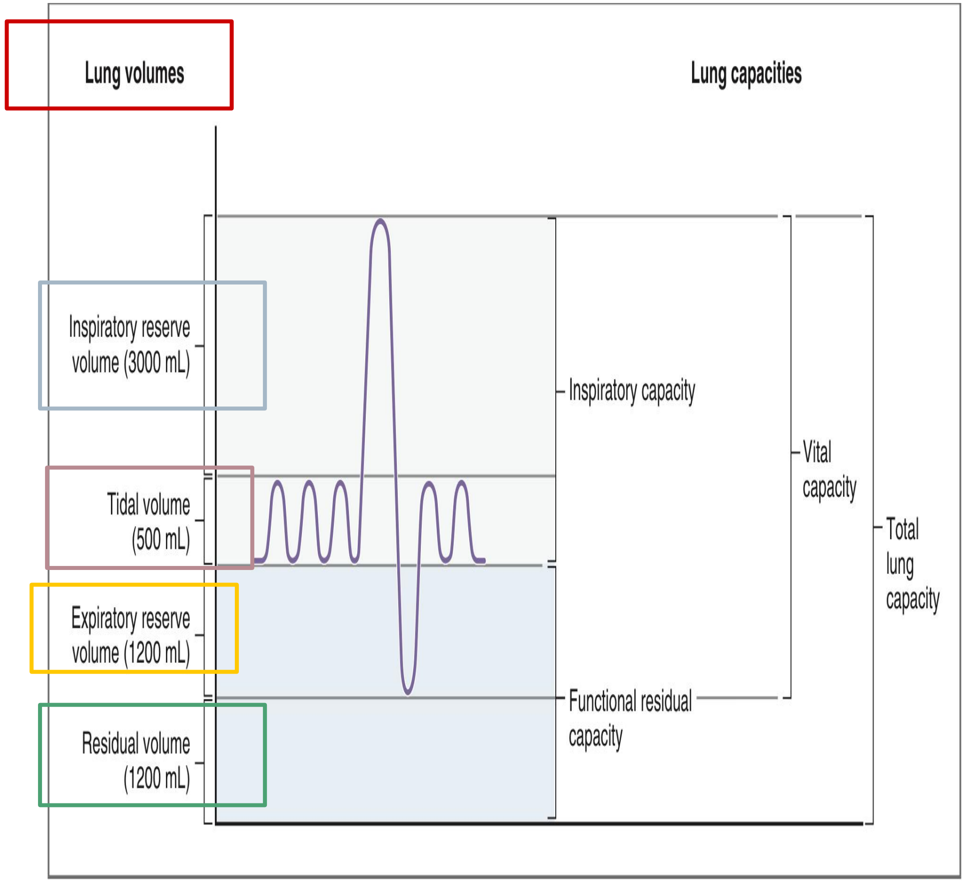


Figure 5-2 Lung volumes and capacities. Measurements of lung volumes and capacities are made by spirometry. Residual volume cannot be measured by spirometry.

Pulmonary capacities

Pulmonary capacities: summation of volumes

Two or more lung volumes are described as pulmonary capacity

Inspiratory capacity (IC):

is the amount of air a person can breathe in, beginning at the normal expiratory level and distending the lungs to the
maximum amount.

IC= TV+ IRV= 500+ 3000= **3500 ml**

The functional residual capacity (FRC):

Is the amount of air that remains in the lungs after normal tidal expiration. Acts as a buffer against extreme changes in alveolar gas levels with each breath.

FRC= ERV + RV= 1100+ 1200= **2300 ml**

Functioning all the time in between the breaths when there is no air enter the lung (constant gas exchange because of the FRC)

In normal expiration the FRC stay in the body

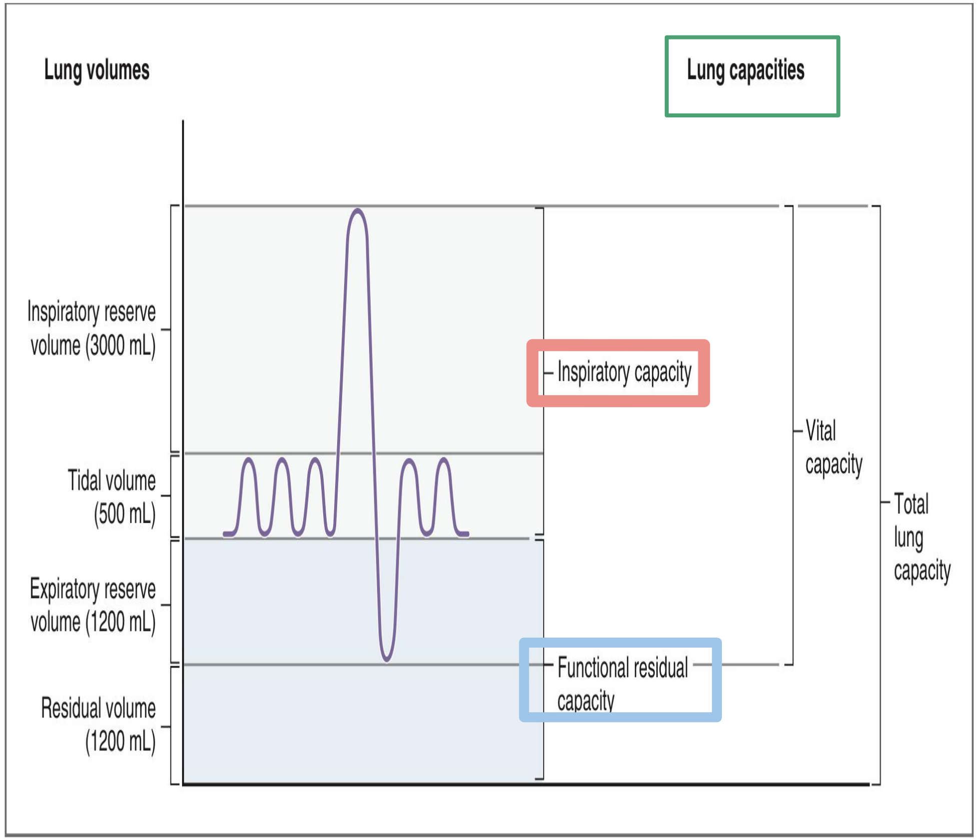


Figure 5-2 Lung volumes and capacities. Measurements of lung volumes and capacities are made by spirometry. Residual volume cannot be measured by spirometry.

Cont.Pulmonary capacities

The vital capacity (VC):
the maximum amount of air a person can expel from the lungs after first filling the lungs to their maximum extent and then recording expiring to the maximum extent.
VC= TV+IRV+ERV =500+3000+1100 =**4600 ml**
يساعدنا نعرف إذا لياقة الشخص كويسه وإذا كانت الرئة والقلب والعضلات تمام أو لا

The total lung capacity (TLC): summation all volumes
is the maximum volume to which the lungs can be expanded with the greatest possible effort
TLC= TV+IRV+ERV+RV = 500+3000+1100+1200= **5800ml**.

All lung volumes and capacities are 20-25% less in women than men , they are greater in large athletic people than in small asthenic* people. (it depend on the size of the person and other factors)
asthenia: abnormal physical weakness or lack of energy

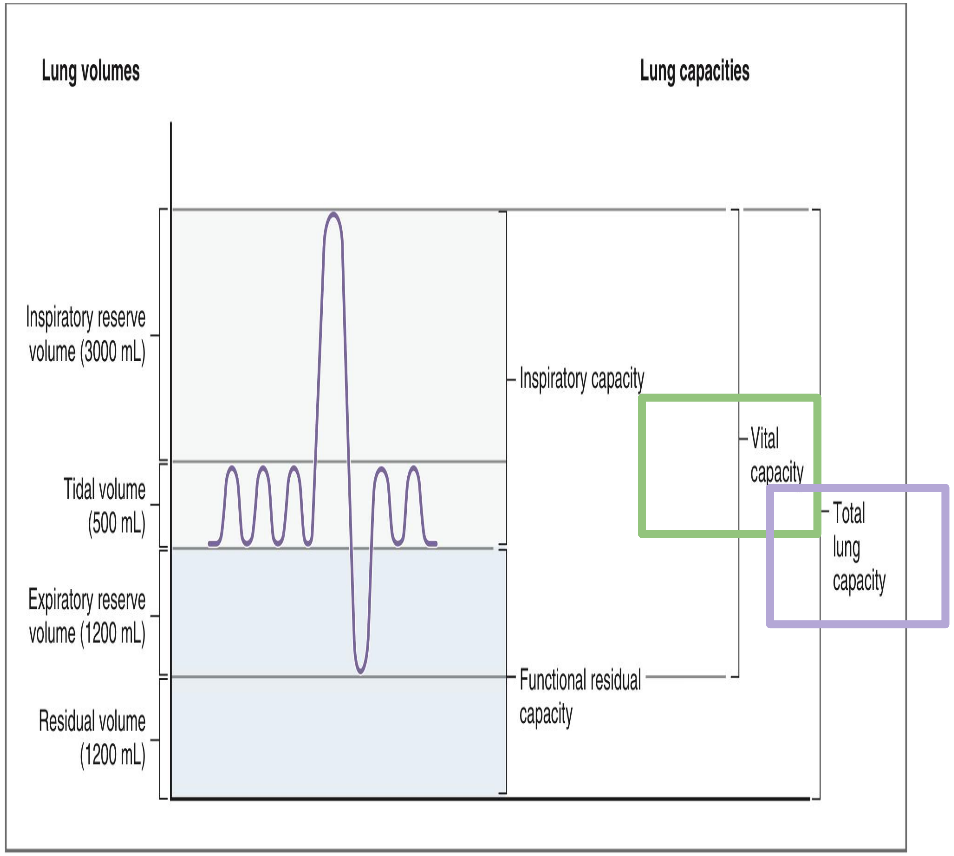
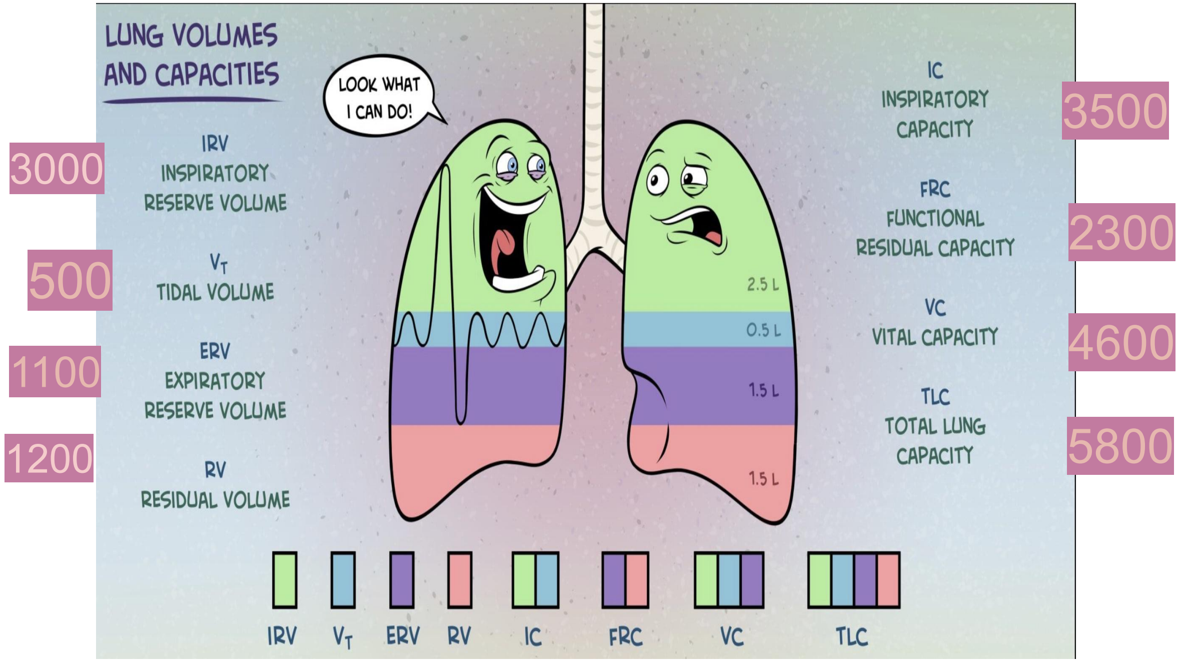


Figure 5-2 Lung volumes and capacities. Measurements of lung volumes and capacities are made by spirometry. Residual volume cannot be measured by spirometry.

Another summary file,[click here]

Summary



Average Pulmonary Volumes and Capacities for a Healthy Young Adult Man

Pulmonary Volumes and Capacities	Normal Values (ml)
Volumes	
Tidal volume	500
Inspiratory reserve volume	3000
Expiratory volume	1100
Residual volume	1200
Capacities	
Inspiratory capacity	3500
Functional residual capacity	2300
Vital capacity	4600
Total lung capacity	5800

Interrelations among pulmonary volumes and capacities

VC = IRV + TV + ERV

VC = IC + ERV

TLC = VC + RV

TLC = IC + FRC

FRC = ERV + RV

Closed circuit Helium Dilution Method

Determination of the FRC, RV, TLC

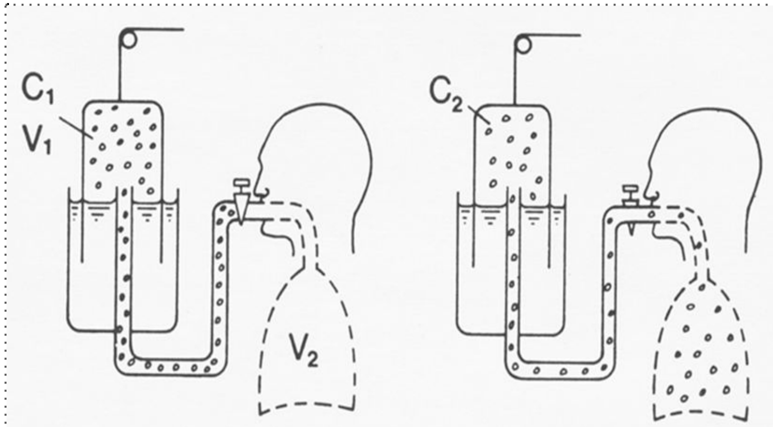
RV can’t be calculated directly like other volumes, so we use helium with the Spirometry
وبالتالي نقدر نحسب الcapacities اللي تعتمد على RV مثل FRC & TLC

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

- C1: concentration of Hi in spirometry
- V1: volume of air in the spirometry
- C2: Final concentration of helium
- V2: Volume of spirometry + FRC

$$FRC = \frac{(Ci\ He\ (C1) - 1)\ Vi\ Spi\ (V1)}{Cf\ He\ (C2)}$$

Is not explained by the doctors



“This method is used to measure the Functional Residual capacity , Total lung capacity and Residual volume and the Helium Analyzer will helps to measure them.

★ Why spirometer can’t measure them?
Because spirometer can ONLY feel the air that have been inspired or expired , and as we mentioned before the residual volume stay in the lung , so the spirometer can’t feel it and the FRC + TLC depend on it.”

How to use the results:

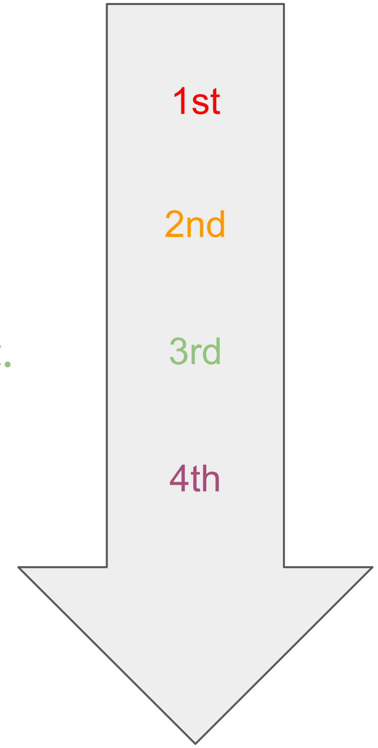
1. Residual volume = FRC - ERV
2. Total lung capacity = FRC + IC

Only in female slide

Forced vital capacity (FVC) and FEV1

Timed vital capacity (FEV1)

- Person asked to inspire as deeply as possible
- Then asked to breath out as hard and as fast as he can.
- The expiration is continued until he expired all the air out.
- Thus forced vital capacity is obtained.



During this process the volume of air expired in the first second is collected and is known as **FEV1**.

Forced Expiratory Volumes

- **FEV1**: The volume of air that can be forcibly expired in the first second.
- **FEV2:** The Cumulative volume expired in 2 seconds
- **FEV3**:the cumulative volume expired in 3 seconds
- Normally, the entire vital capacity can be forcibly expired in 3 seconds,so there is no need for FEV4
- FVC and FEV1 are useful indices of lung disease.

What is the benefit of using FEV1/FVC ?

Specifically, the fraction of the vital capacity that can be expired in the first second, FEV1/FVC can be used to differentiate among diseases.

- FEV1/FVC in normal person is 0.8

What does that mean?

80% of the vital capacity can be expired in the first second of forced expiration

FEV1/FVC ratio

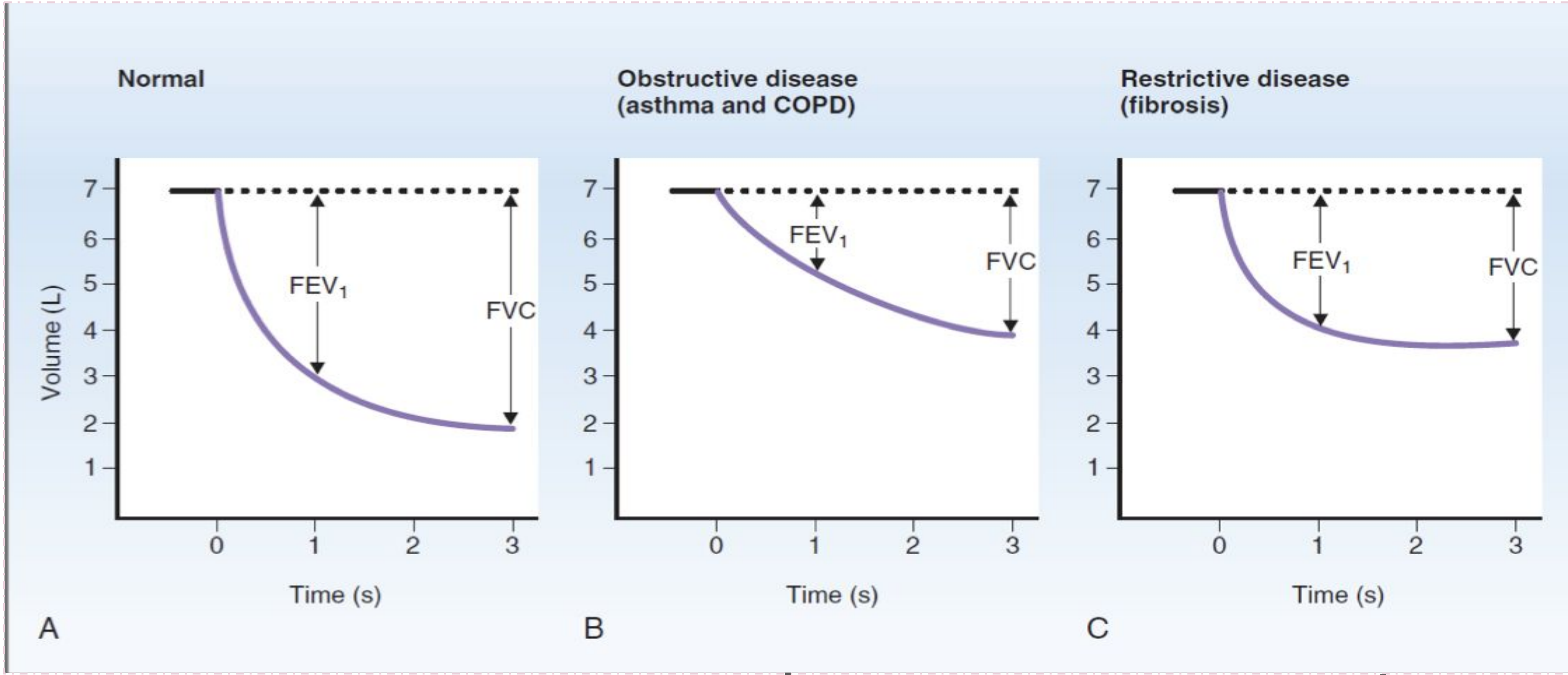
Normally it is about 80%.

- Importance: This ratio differentiate between obstructive and restrictive lung diseases

Restrictive lung diseases	Chronic Obstructive lung disease COPD is typical of airway obstruction with its increased resistance to expiratory air flow.
FEV1/FVC ratio Normal/increased The ratio More than Normal "More than 0.8"	FEV1/FVC ratio Decreases We said the normal FEV1/FVC ratio is 0.8 (80%) But in this case is less than 0.8
FVC Decrease comparestion to normal	FVC decrease
FEV1 Decrease less than FVC comparestion to normal	FEV1 decrease more than FVC
TLC decrease	TLC increase
RV decrease	RV increase
e.g interstitial pulmonary fibrosis	e.g bronchial asthma, emphysema

Helpful video click here

Cont.FEV1/FVC ratio



طبعًا هنا مثال عليها الemphysema واحنا قلنا قبل ان في حاله الemphysema الالفولاي عندها high compliance بمعنى تقدر تتمدد وأكثر من الطبيعي ف يعني تقدر تدخل هواء عالي بس هل تقدر تطلع الهواء بشكل طبيعي ؟ الجواب لا لان ما يصير لها collapse ف نقدر نستنتج ان FEV1 بيكون منخفض

Patient in this condition They can inspire (because inspiration is always active) and this will overcome the airway resistance However, they find difficulty in expiration due to this high airway resistance. Therefore they are breathing by forced expiration also So FEV1 will decrease .

Restrictive and Obstructive Lung Diseases

The figure below shows pathologic states in which lung compliance changes.

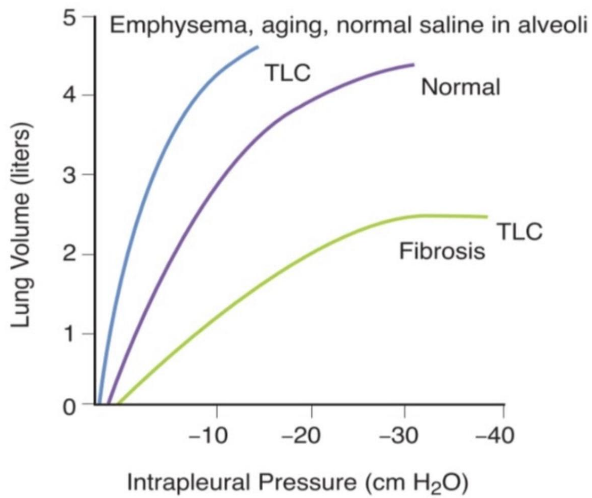


Figure V-1-10. Lung Compliance

Obstructive and Restrictive diseases:
Now that you know the different pressures at the different steps of respiration, Obstructive and Restrictive diseases can be explained in a very simple concept.

Obstructive disease (Emphysema):
the patient will have difficulty creating a positive alveolar pressure (+1) during expiration. That is caused by the decrease in elasticity (recoil) in the lung, and thus an increase in compliance.

Restrictive disease (Fibrosis):
the patient will have difficulty creating a negative alveolar pressure (-1) during inspiration. That is caused by an increase in elasticity (recoil) in the lung, and thus a decrease in compliance.

As you can see in the graph, emphysema has a higher TLC because of the increased compliance, while Fibrosis has a decreased TLC.

Minute ventilation volume

Minute respiratory volume (MRV):

- Total amount of air moved into and out of respiratory system per minute.
- Equation= Respiratory rate (RR) x Tidal volume (TV) = 12 X 500ml = 6l/min (6000ml/min)

Respiratory rate"RR":
Number of breaths taken per minute.
[Approximately 12-18/ min]

- MRV could **rise** to 200 L/min or more than 30 times normal if RR = 40, TV = 4600 ml in young adults man.

Dead space and its effect on alveolar ventilation

Dead space: is the volume of air in the conducting passages (not participating in gas exchange).

Anatomical dead space

volume of air present in the conducting respiratory passages (150 ml)=1/3 of tidal volume. {On expiration, this air is expired first, before any of the air from the alveoli reaches the atmosphere}

Functional dead space

(Non functioning alveoli)

alveoli that cease to act in gas exchange due to collapse or obstruction or because they are not perfused by capillary blood supply.

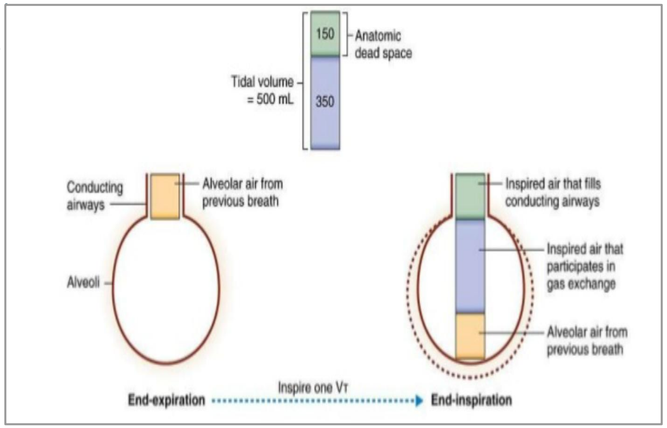
In healthy subjects both anatomical dead space = Physiological dead space.

Physiological dead space

summation of non functioning alveoli and anatomical dead spaces.

احنا عرفنا ان الtidal volume يساوي 500 بشكل طبيعي اللي يشارك في تبادل الغازات 350 اللي هو يساوي ثلثين ال500 الباقي اللي هو 150 يساوي ثلث ال 500 ما يشارك لذالك نسميه anatomical dead space

في حاله functional dead space ال 350 من الهواء اللي كان طبيعي يشارك في تبادل الغازات راح يقل إلى 300 ويصير 50 ما يشاركون "طبعاً هذي حاله مو طبيعيه ومو دايم تصير" واحنا already عندنا ال anatomical dead space اللي يساوي 150 يعني ال physiological dead space يساوي 50+150=200



Alveolar ventilation

Rate of alveolar ventilation per min:

Is the total volume of new air entering the adjacent gas exchange area each minute.

=

(TV(tidal volume) - Dead space volume) x RR

=

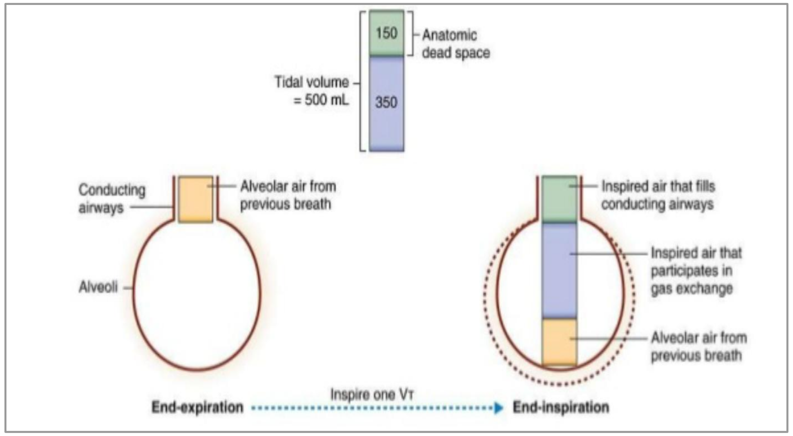
(500-150) x 12 = 350 x 12 =
4200ml/min (4.2L/min)

RR = Rate Respiratory

احنا عرفنا فوق عن طريق Minute respiratory volume ان كميه الهواء بالكامل اللي يدخل ويطلع في الدقيقة سواء يشارك بالتبادل الغازات أو ما يشارك 6000 "بالملي" لكن في القانون هذا يساعدنا نعرف حجم الهواء اللي يشارك في تبادل الغازات في الدقيقة بمعنى من دون الdead space ف عرفنا انه 4200 طيب لو نبغى نعرف اللي مايشارك بتبادل الغازات ؟
6000-4200=1800 من الهواء يدخل ويطلع في الدقيقة ما يشارك في تبادل الغازات
ومهم نعرف ان الهواء اللي مايشارك في تبادل الغازات موجود في الconductive zone يعني يسوي الوظائف اللي ذكرناها في لتكشر ون مثل الصوت والخ...

is one of the major factors determining the concentrations of oxygen and carbon dioxide in the alveoli.

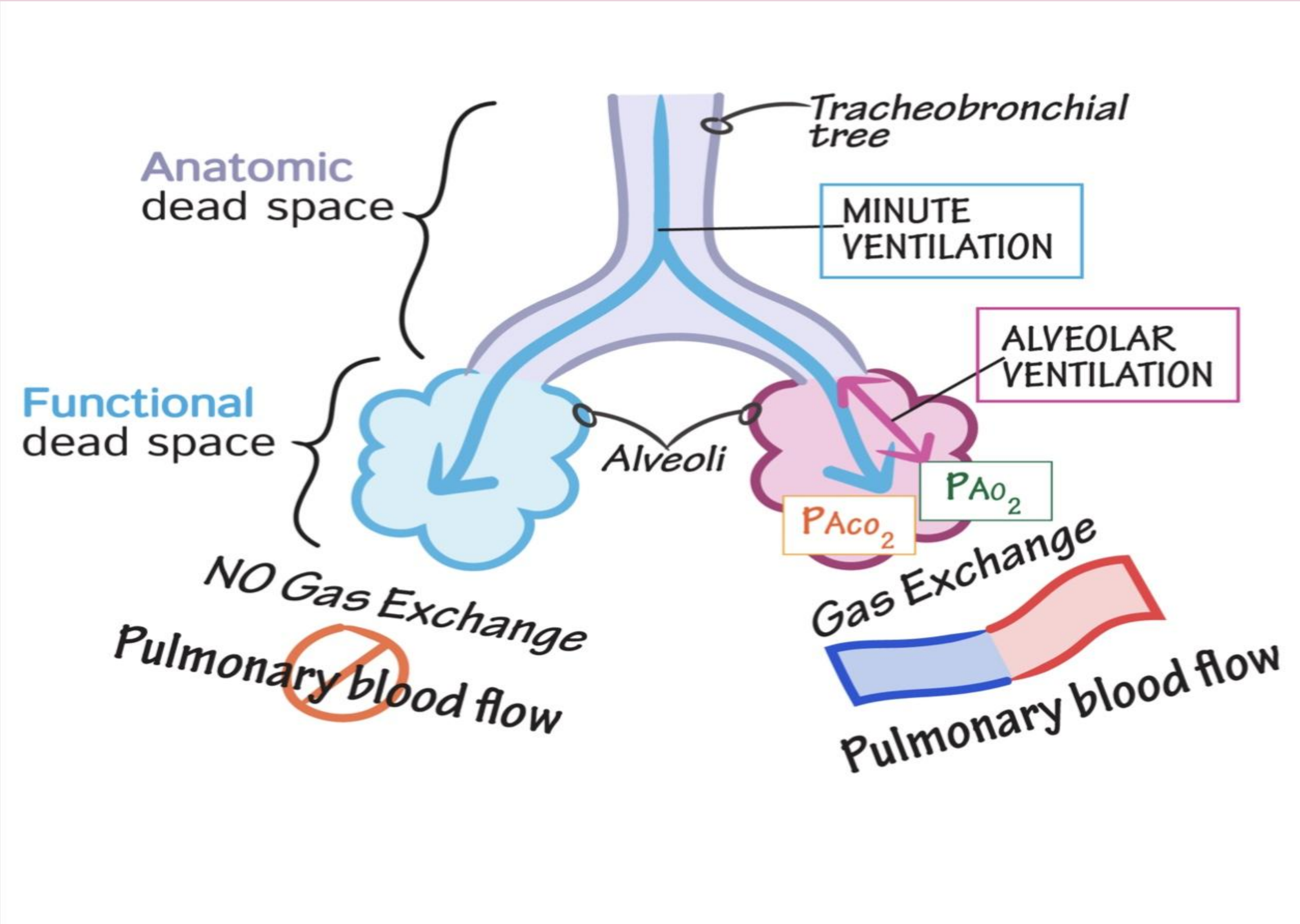
بمعنى لو كان ال alveolar ventilation طبيعي أنا اقدر أخمن واعرف ان الاوكسجين كميته كويسه في جسمي و Co2 جالس يطلع بكميه كويسه بعد



Form Guyton

The ultimate importance of pulmonary ventilation is to continually renew the air in the gas exchange areas of the lungs, where air is in proximity to the pulmonary blood. These areas include the alveoli, alveolar sacs, alveolar ducts, and respiratory bronchioles. The rate at which new air reaches these areas is called alveolar ventilation

Summary



Tracheobronchial tree
Anatomic dead space
MINUTE VENTILATION
ALVEOLAR VENTILATION
Functional dead space
Alveoli
PAO2
PACO2
NO Gas Exchange
Pulmonary blood flow
Gas Exchange
Pulmonary blood flow

Quiz

You don't understand why we choose this answer?
Click here for explanation

1- By a routine examination of respiratory functions a spirometer is used to measure lung volumes. Which lung volume or capacity can not be determined by this method?

A. Vital capacity
B. Expiratory reserve volume
C. Total lung capacity
D. Inspiratory reserve volume

	Normal	Obstructive disease	Restrictive disease
FVC	Normal	↓	↓↓
FEV1	Normal	X	↓
FEV1/FVC	0.8	↓	Y

2.Complete the boxes labeled X and Y?

A. X: Normal or increased Y: decreased
B. X: decreases more than FVC Y: normal or increased
C. X: decreases less than FVC Y: normal or increased
D. X: increases Y: increases

3- 1- A patient has a dead space of 150 milliliters, FRC of 4 liters, TV of 650 milliliters, IRV of 2.5 liters, TLC of 8 liters, and respiratory rate of 13 breaths/min. What is the alveolar ventilation (Va)?

A. 6500 l/min
B. 8450 l/min
C. 7000 ml/min
D. 8450 ml/min

4. Complete the following equations:

X=IC+FRC

FRC=RV+Y

VC=IC+Z

A. X=TLC,Y=ERV, Z=IRV
B. X=TV, Y=ERV, Z=TLC
C. X=TV, Y=IRV, Z=TLC
D. X=TLC, Y=ERV, Z=ERV

Key Answers :
4: D
3: A
2: B
1: C

SAQs

1.Describe the types of dead spaces in the respiratory system?

2.A patient has a dead space of 150 milliliters, FRC of 4 liters, TV of 650 milliliters, IRV of 2.5 liters, TLC of 8 liters, and respiratory rate of 13 breaths/min. What is the minute respiratory volume(MRV)?

1.Anatomical dead space: volume of air in the conducting respiratory passages

Functional dead space: Collapsed alveoli (Pathological)

Physiological dead space: summation of anatomical and functional dead spaces

2.MRV = Respiratory rate x Tidal volume
= RR X TV
= 13 X 650=8.45L/min =8450ml/min

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