PHYSIOLOGY TEAM 435

3 Respiratory Ventilation

- Very important
- Extra information
- Terms

The more you can dream ,the more you can do!

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Objectives

By the end of the lecture you should be able to: -

- Define the various lung volumes and capacities and provide typical values for each.
- Define ventilation rate, their typical values, and their measurement.
- Describe FEV1 and its role in differentiating obstructive and restrictive lung diseases.
- Describe the types of dead space. State a volume for the anatomical dead space.
- Define the term minute ventilation and state a typical value.
- Distinguish minute ventilation from alveolar ventilation.

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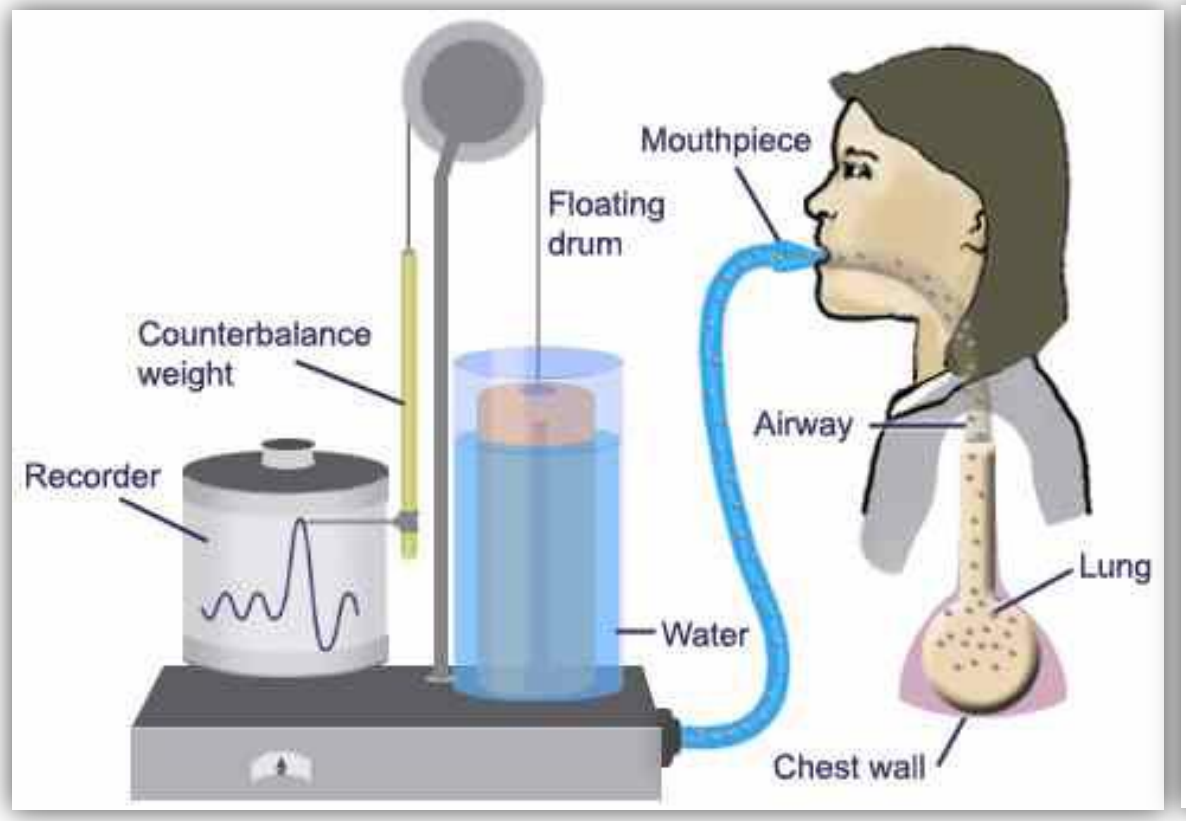
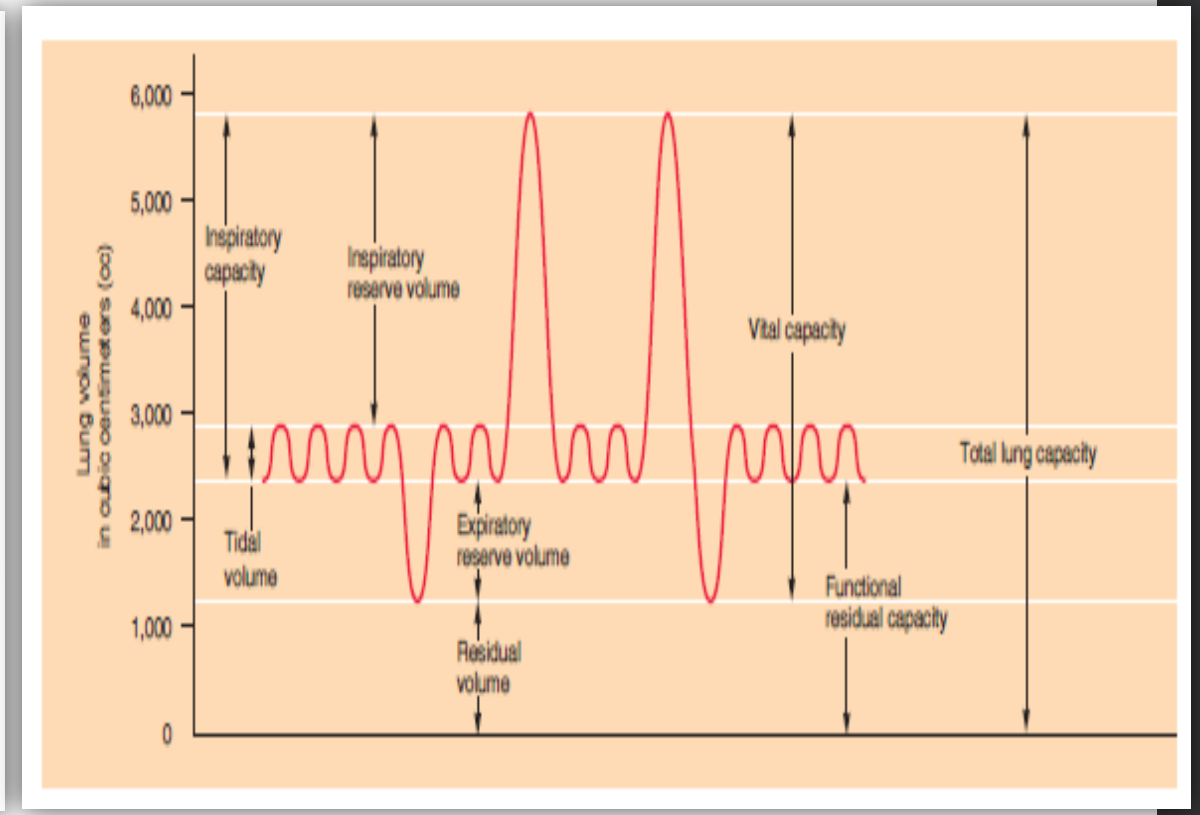
Spirometry & Spirogram

Spirometry is a method for measuring the volume and the flow of air that can be inhaled and exhaled.
Called : "student spirometry" or "wet spirometry"
Boy's Note : Is recording the volume movement of air into and out of the lungs.

Spirogram is the drawing of the spirometry.
Boy's Note : For ease in describing the events of pulmonary ventilation, the air in the lungs has been subdivided in this diagram into four volumes and four capacities.





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Lung volumes

- The total volume contained in the lung at the end of a maximal inspiration is subdivided into volumes and subdivided into capacities .
- The lungs have 4 main volumes:

Tidal Volume (TV)	The amount of air inspired or expired with each normal breath	500 ml
Inspiratory Reserve Volume (IRV)	Is the extra volume of air that can be inspired over and above the normal tidal volume when the person inspires with full force. OR the maximum amount of additional air that can be inspired from the end of a normal inspiration.	3000 ml
Expiratory Reserve Volume (ERV)	Is the maximum extra volume of air that can be expired by forceful expiration after the end of a normal tidal expiration. OR the maximum volume of additional air that can be expired from the end of a normal expiration.	1100 ml
Residual Volume (RV)	The volume of air remaining in the lung after a maximal expiration. This is the only lung volume which cannot be measured with a spirometer.	1200 ml

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Lung Capacities
(Pulmonary capacities)

Two or more lung volumes are described as pulmonary capacity.

Inspiratory Capacity (IC)	Is the amount of air a person can breath in, beginning at the normal expiratory level "end expiratory position" and distending the lungs to the maximum amount .	IC= TV+IRV 500+3000 =3500 ml
Functional Residual Capacity (FRC)	-The volume of air remaining in the lung at the end of a tidal expiration. -Acts as a buffer against extreme changes in alveolar gas levels with each breath.	FRC= RV+ERV 1100+1200= 2300 ml
Vital Capacity (VC)	The maximum volume of air that can be forcefully expelled from the lungs following a maximal inspiration.	VC= IRV+TV+ERV 500+3000+1100 = 4600 ml
Total Lung Capacity (TLC)	The volume of air contained in the lungs at the end of a maximal inspiration. Or with the greatest possible effort.	TLC= ALL OF THE VOLUMES = 5800 ml

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"EXTRA NOTES"

Functional residual capacity: it's called functional because it has a main function, it's maintain gas exchange in between breaths even we don't take a new breath.

-عند أخذ الشهيق والزفير بعد الانتهاء يوجد فترة بسيطة لا يدخل فيها الهواء ،وعملية gas exchange لابد أن لاتتوقف عن العمل أبداً .. بالتالي الFRC يعمل على دعم العملية حتى نأخذ النفس الجديد(هواء احتياطي) بالتالي يمنع التغيرات في مستوى الأوكسجين وثاني أكسيد الكربون في الدم ،فيحتفظ بمستواهما الطبيعي في جميع الأوقات.

Vital capacity : is the longest line on the spirogram. and it's only associated with lung volumes that moves in and out.

Total capacity = Functional residual C. + Inspiratory C.

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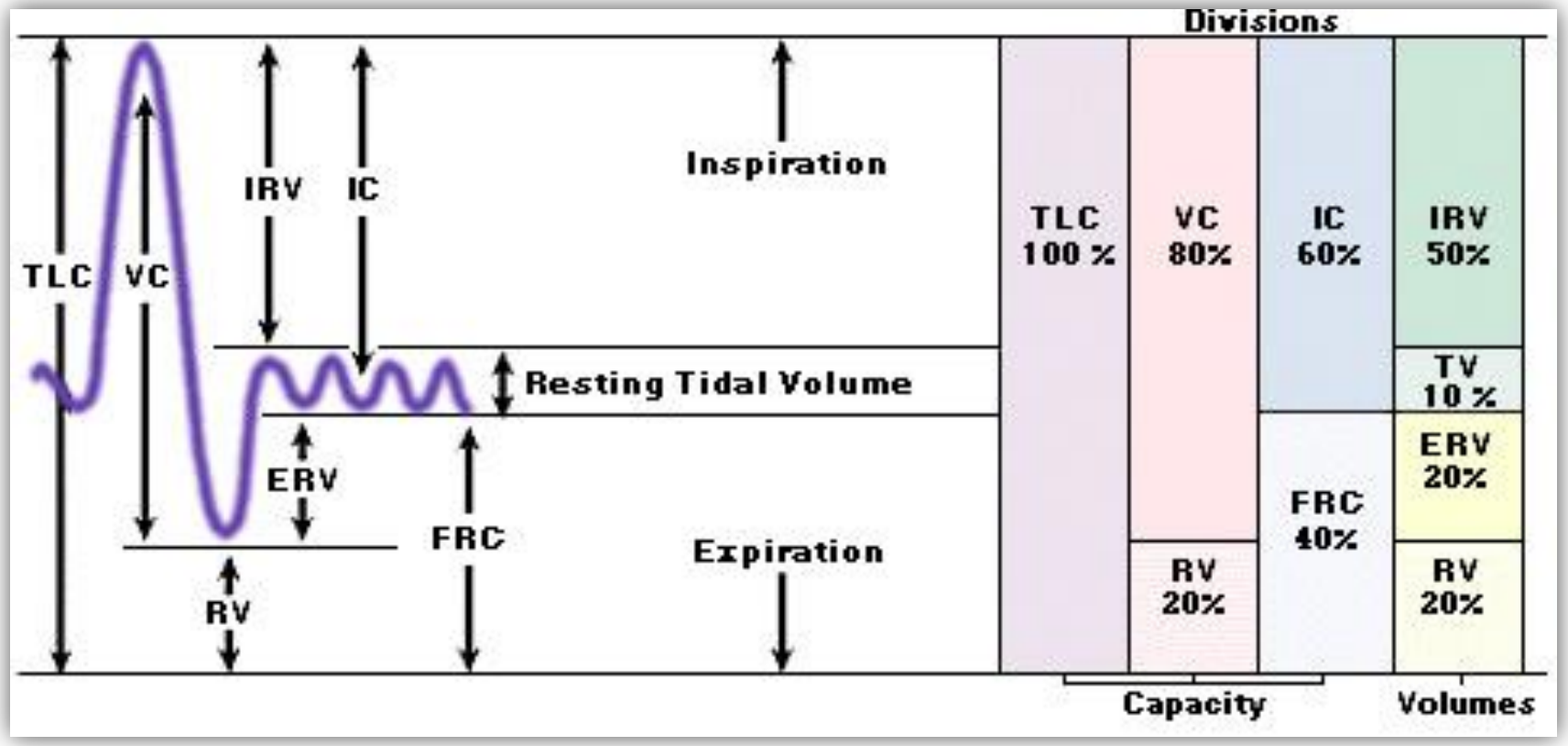
Lung Capacities



- All lung volumes and capacities are 20-25% less in women than men, they are greater in large athletic people than in small athletic people.

Determination of the FRC, RV, TLC

We use Closed Circuit Helium Dilution to Determine FRC , RV and TLC .

concentration of Hi in spirometry

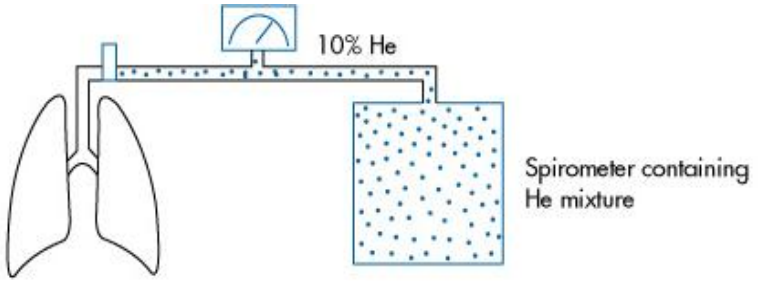
Final concentration of helium

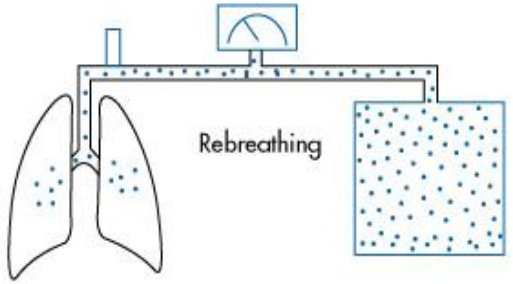
C1 x V1 = C2 x V2

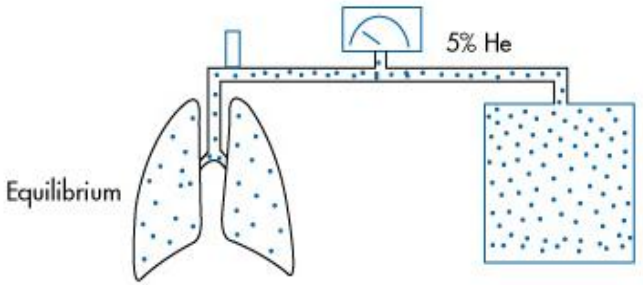
volume of air in the spirometry.

Volume of spirometry + FRC

$$FRC = \left(\frac{C1}{C2} - 1\right) \times V1$$

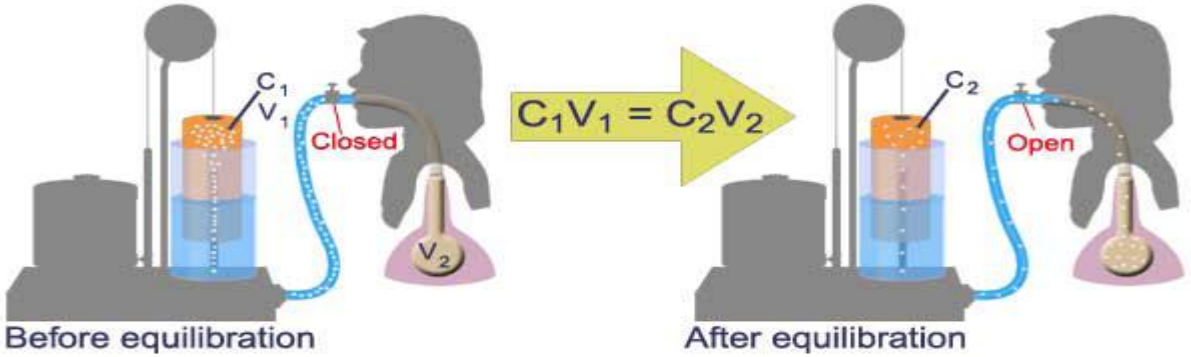






Why do we choose He ?
Because Hi is from the inner gases ,when it's enter our body it doesn't diffusion ,that means we don't use it! It's only a gas that takes place without any function.

Determination of the FRC, RV, TLC "Example & Boy's Notes"



EXAMPLE:
C1= 10%
V1= 2L(2000ml)
C2 = 5%
V2 = ?
RV = ?

-V2 = FRC = (C1 / C2 -1) x V1
(10 / 5 -1)x 2000 = 2000ml
So, when the Hi concentration reduced to the half that means V1 = V2 (5% in V1 .. 5% in V2)
- RV = (FRC – EXV) = 2000 – 1100 = 900ml.

The functional residual capacity (FRC), which is the volume of air that remains in the lungs at the end of each normal expiration, is important to lung function. Because its value changes markedly in some types of pulmonary disease, it is often desirable to measure this capacity. **The spirometer cannot be used in a direct way to measure the functional residual capacity because the air in the residual volume of the lungs cannot be expired into the spirometer**, and this volume constitutes about one half of the functional residual capacity. To measure functional residual capacity, **the spirometer must be used in an indirect manner, usually by means of a helium dilution method,** as follows.
A spirometer of known volume is filled with air mixed with helium at a known concentration. Before breathing from the spirometer, the person expires normally. At the end of this expiration, the remaining volume in the lungs is equal to the functional residual capacity. At this point, the subject immediately begins to breathe from the spirometer, and the gases of the spirometer mix with the gases of the lungs. As a result, the helium becomes diluted by the functional residual capacity gases .
Once the FRC has been determined, the residual volume (RV) can be determined by subtracting expiratory reserve volume (ERV), as measured by normal spirometry, from the FRC. Also, the total lung capacity (TLC) can be determined by adding the inspiratory capacity (IC) to the FRC.

Just read it !! you will understand all about this method.

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FVC and FEV1

- **Foreced Vital Capicity (FVC)**: The volume that after a full inspiration then expire with the most force and speed .
- **Timed vital capacity (TVC) :** The person is asked to inspire as deeply as possible and then to breath out as hard and as fast as he can. The expiration is continued until he expired all the air out and thus forced vital capacity Is obtained.

- During this process the volume of air expired in the first second is collected and is known as **Forced Expiratory Volume in 1st second (FEV1)**

- **The normal FEV1/FVC Ratio is 80%**

- This ratio **differentiate** between obstructive and restrictive lung diseases.

Obstructive And Restrictive Lung Diseases

Obstructive Ventilatory Defect :

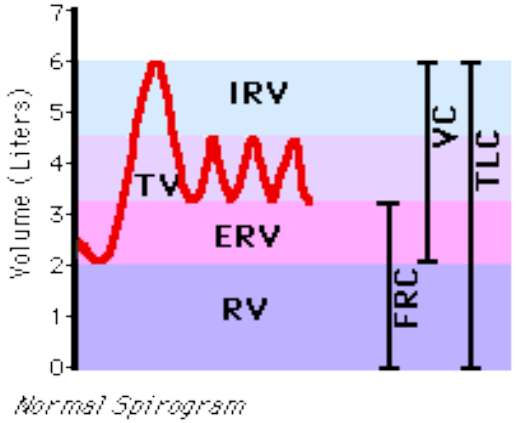
The ratio is Less than 80%

Decrease → VC

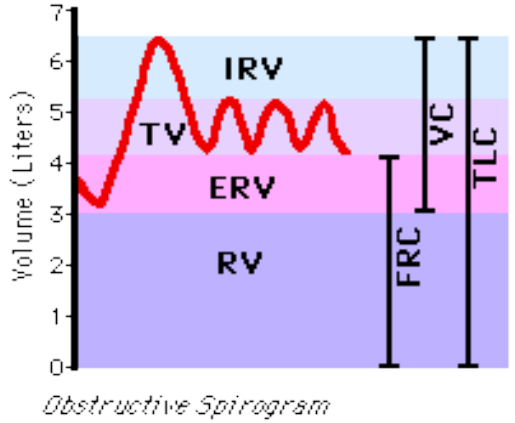
Increased → TLC, RV, and FRC

Increase airways resistance.

e.g. Bronchial asthma, Emphysema



Normal Spirogram



Obstructive Spirogram

Restrictive Ventilatory Defect :

-The ratio is Normal = 80%

but decreased lung volume.

-There is No increase airways resistance.

- The problem is no enough space for air in the alveoli, due to the accumulation of fibrous tissue between the alveoli.

e.g. Interstitial Pulmonary Fibrosis

The normal person and the restrictive person all have normal ratio. How do we differentiate between them?
By the total lung volume. It's decreased in restrictive person.

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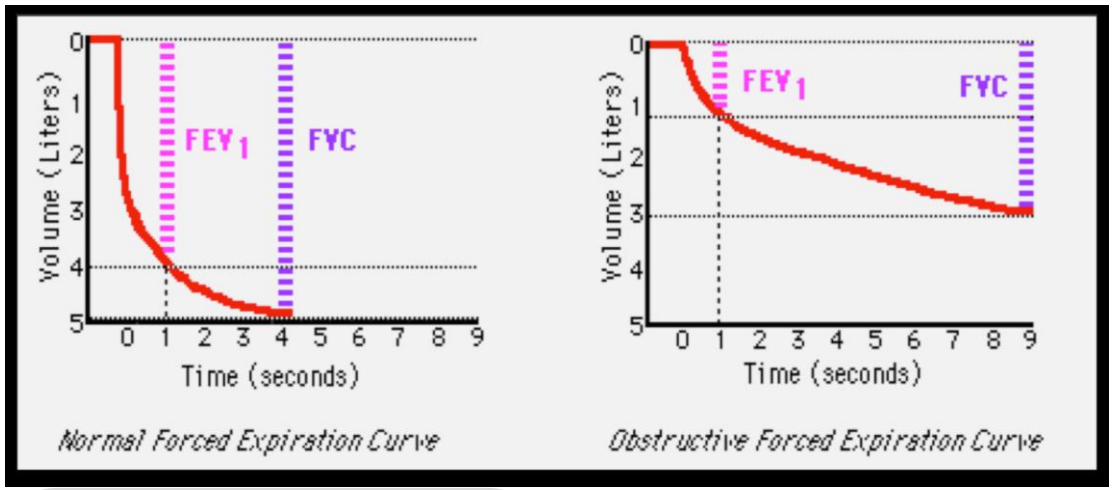
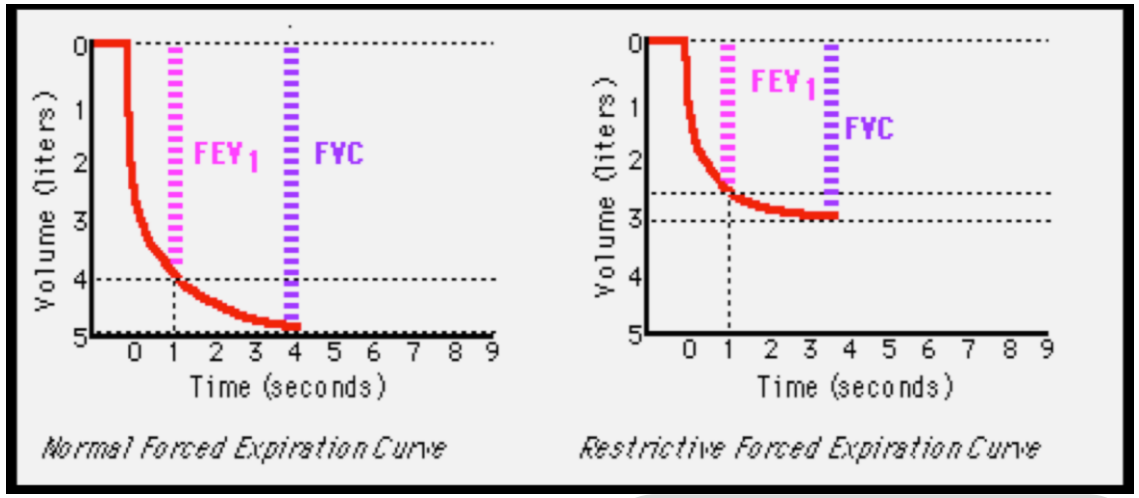
Obstructive And Restrictive Lung Diseases

Obstructive Ventilatory Defect :

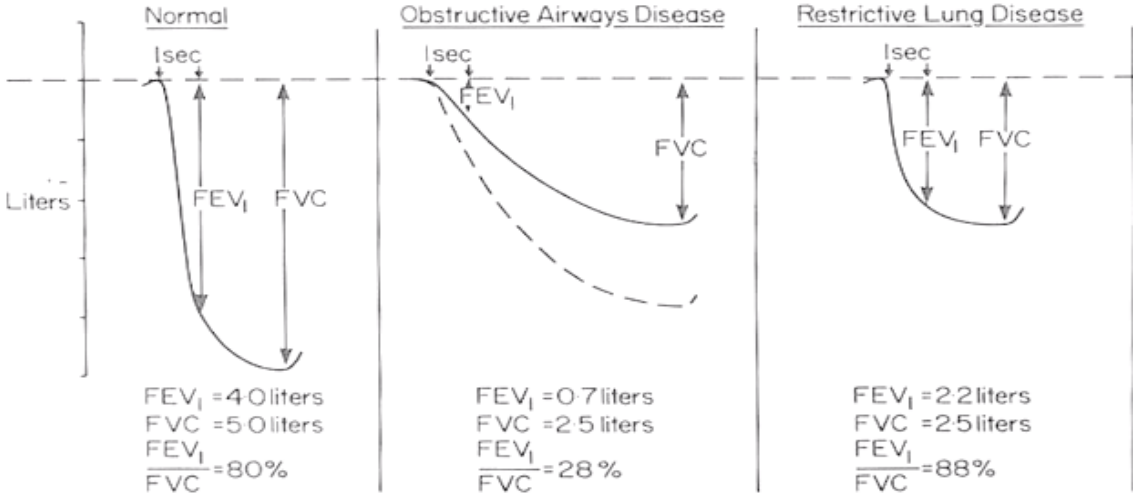


-FEV1 is abnormal ~ 50%
-The time is abnormal, it's increased to 9s!
-FVC is abnormal it's reduced from 5L to 3L.

Restrictive Ventilatory Defect :



-FEV1 is normal = 80%
-The time is normal = 4s
-FVC is abnormal it's reduced from 5L to 3L.



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Dead space

Anatomical dead space	Functional dead space
The portion where there <u>is no possibility</u> of gas exchange (conductive zone) The air present in conductive zone = 150 ml.	The portion where there <u>is possibility</u> of gas exchange but its not happening <u>Due to absent or poor blood flow</u>

Physiological dead space

Anatomical and functional dead spaces together defines the physiological dead space.

-"Dead Space" and Its Effect on Alveolar Ventilation.

Some of the air a person breathes never reaches the gas exchange areas but simply fills respiratory passages where gas exchange does not occur, such as the nose, pharynx, and trachea.

This air is called dead space air <u>because it is not useful for gas exchange.</u>

On expiration, the air in the dead space is expired first, before any of the air from the alveoli reaches the atmosphere.

Therefore, the removing the expiratory gases from the lungs.

-Tidal volume = 500 (150 in conductive zone) & (350 in respiratory zone)

-**For example :** Anatomical dead space=150 & Functional dead space=50

The physiological dead space = 150 + 50 = 200

- In <u>Abnormal people</u> the anatomical dead space 150 < Physiological dead space 200 (Due to Poor blood flow)
- In <u>normal people</u> the anatomical dead space150 = Physiological dead space150 (NO poor blood flow)

Just read it. To understand the whole idea.

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Minute respiratory volume (MRV)

- The minute respiratory volume: is the total amount of new air moved **into the respiratory passages** each minute. It is equal to the tidal volume times the respiratory rate per minute.

MRV = TV (tidal volume) X RR (respiratory rate)

MRV = 500 × 12 = 6 L/min

- Normal TV = 500 , normal RR = 12 breaths per minute.
- However It could rise until 200 L/min or more than 30 times normal , if RR= 40 and TV= 4600 ml in young adult man.

-A person can live for a short period with MRV as low as 1.5 L/min and RR of only 2-4 breaths per minute.

Alveolar ventilation

- Rate of alveolar ventilation per min : is the total volume of new air **entering the alveoli and adjacent gas exchange** area each minute. It is equal to the respiratory rate times the amount of new air that enters these areas with each breath.

Rate of alveolar ventilation per min = (TV - Dead Space Volume) X RR

= (500 – 150) X 12 ⟶ = 350 X 12 ⟶ = 4200 ml/min

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

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The differences between the (MRV) & alveolar ventilation "EXTRA"

Minute Respiratory Volume	Alveolar Ventilation
Per Minute.	
New air moves into **"The respiratory passages"**	New air into **"The alveoli and adjacent gas exchange"**
MRV= TV (tidal volume) X RR (respiratory rate)	AV = (TV - Dead Space Volume) X RR
It is equal to the tidal volume times the respiratory rate/min.	It is equal to the respiratory rate times the amount of new air that enters these areas with/breath.

PHYSIOLOGY TEAM 435

4 Lung functions in health and disease : Spirometry

- Very important
- Extra information
- Terms

You must do the thing you think you cannot DO!

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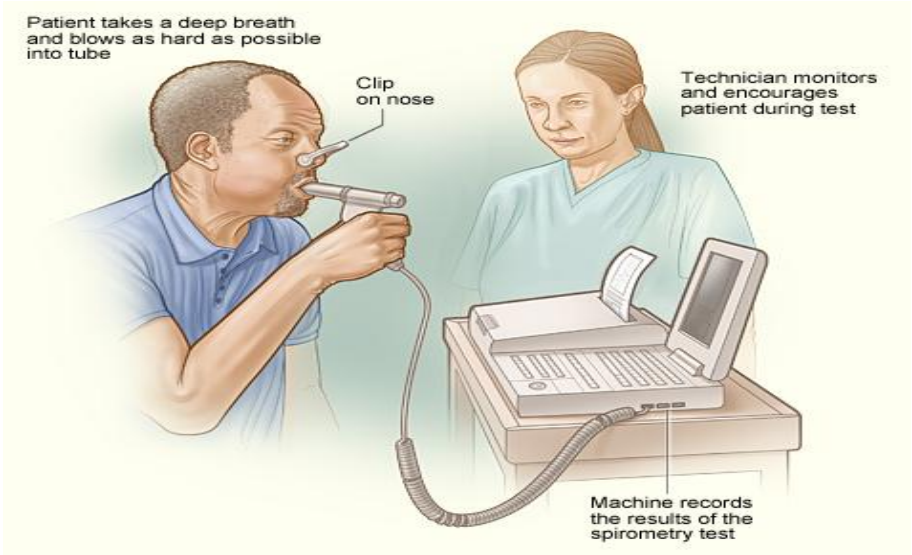
Spirometry

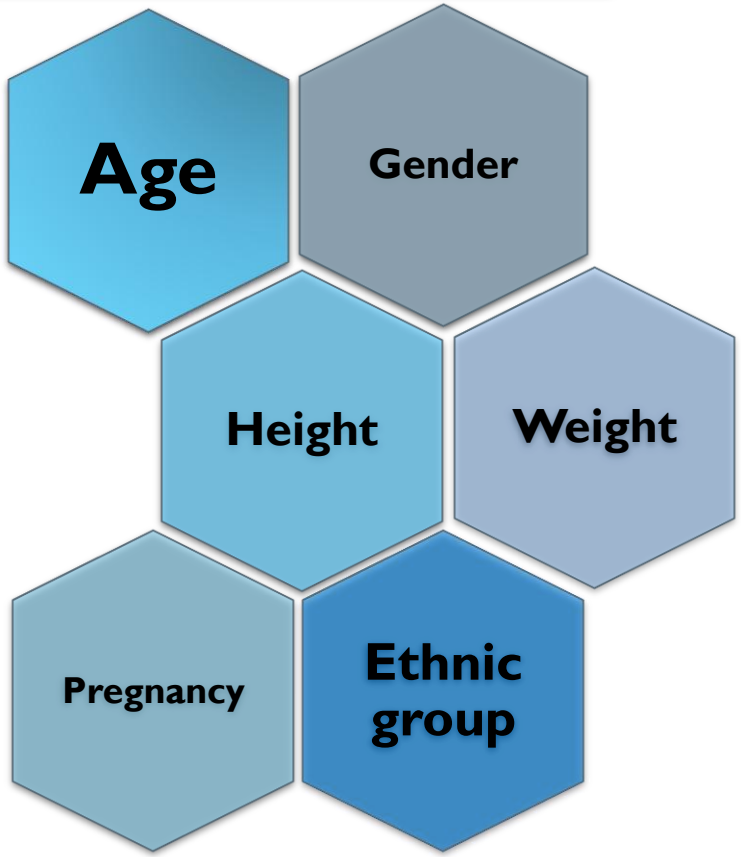
- Spirometry is a widely used, effort depended basic lung function test. (means, depend on the muscles' power of the patient)
- Assess the lung performance. (يقيّم أداء الرئة ووظائفها)
- Assess physiological parameters; lung volumes, capacities & flow rate.
- Differentiate between the obstructive and restrictive lung conditions.
- Play a critical role in the diagnosis, differentiation and management of respiratory illness.



Physiological conditions and Spirometry

When using spirometry, you should keep these in your consideration (because results can be different):

Age : the lung volumes & capacities values in fetus different from the adult. We know that the maximum effort is in adulthoods. Then after 30 age will decrease again.
Height : Longer > longer chest > More lung volumes & capacities.
Weight : More obese > More excessive fat in abdomen > press on diaphragm "decrease chest volume" > limited lung function.
Pregnancy : Large uterus > press on diaphragm "decrease chest volume" > also limited in lung functions.



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Indications of spirometry

Based on **clinical features**, **abnormal lab tests** or **abnormal chest X rays.**

Symptoms

- Dyspnea
- Cough
- Sputum production
- Chest pain

Signs

- Cyanosis
- Clubbing
- Chest deformity
- Diminished chest expansion
- Hyperinflation
- Diminished breath sounds
- Prolongation of expiratory phase & crackles
- Arterial blood analysis: Hypoxemia + Hypercapnia

Hyperinflation > تضخم في التجويف الصدري
Crackles > صوت خشخشة عند التنفس
Hypoxemia > Low O2 Level in blood.
Boy's Note: Hypoxemia is common in patients with hypercapnic respiratory failure who are breathing room air.
Hypercapnia > High CO2 level in bood.
Dyspnea or dyspnoea > shortness of breath or breathlessness.
Sputum > بلغم

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Indications of spirometry

Other indications:

1- Know the courses of some diseases that affect pulmonary function tests (PFTs) :

Neuromuscular diseases	• Guillain barre syndrome • Myasthenia gravis
Pulmonary diseases	• Obstructive airway diseases • Interstitial lung diseases
Adverse drug reactions	•Drugs with pulmonary toxicity (Pulmonary fibrosis)

2-To assess the therapeutic interventions:

- Bronchodilator therapy
- Steroid treatment for asthma
- Chronic obstructive lung disease (COPD)
- Interstitial lung disease

3- Pre-operations:

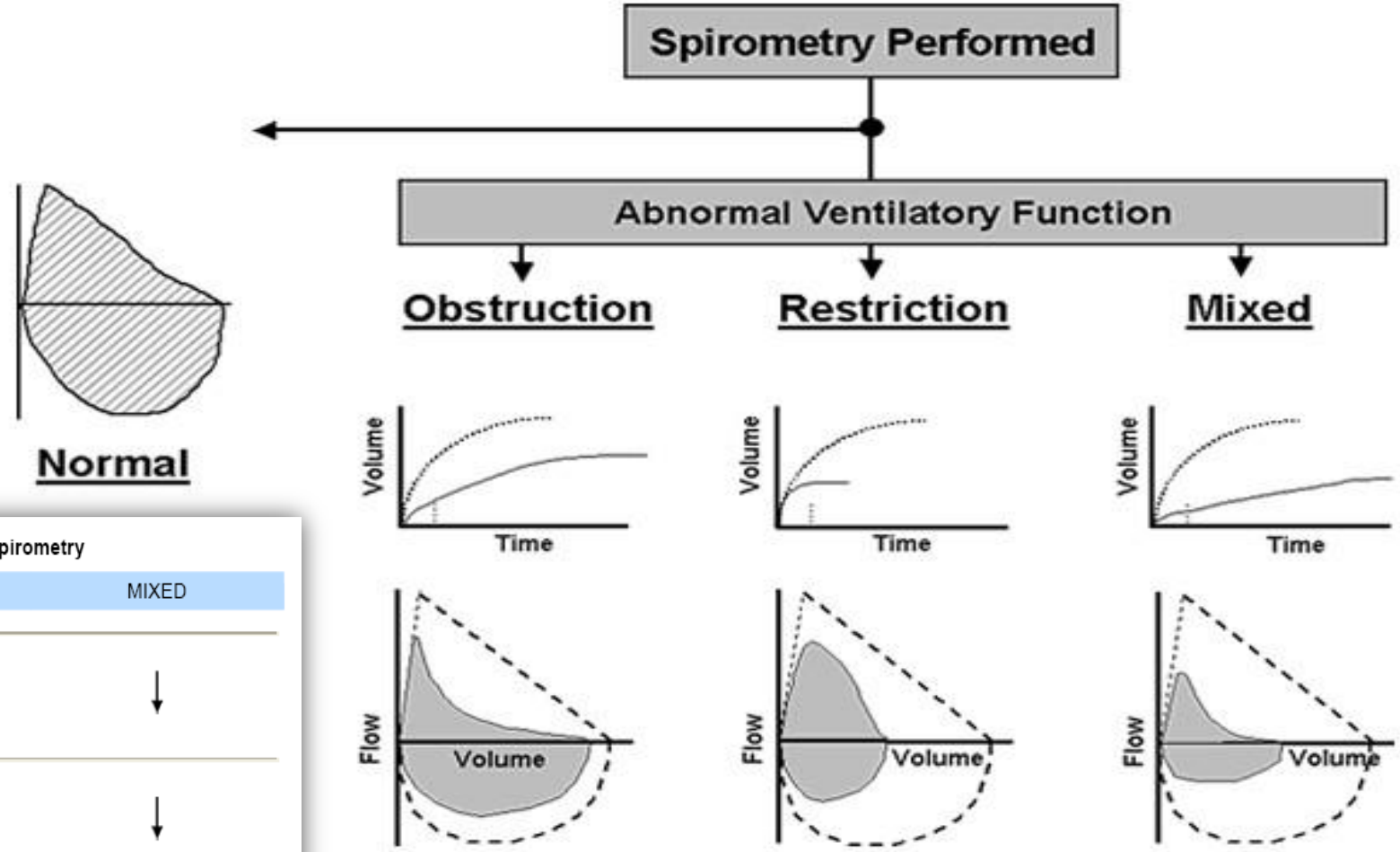
•To assess the risk for surgical procedures known to affect lung function.

•To determine the suitability and management during and after anesthesia.

•In patients with obstructive lung diseases where there is incomplete emptying of the lungs and air trapping, RV may be significantly increased. Patients with high RV who require surgery and mechanical ventilation require high peri-operative inflation pressures.

Just read it. Boy's Note.

Spirometry in respiratory diseases



In obstruction :
-Prolongation in time, due to increase airways resistance.

In restrictive :
-Decrease total lung volume of air, due to the accumulation between alveoli.(Ex. Fibrosis)

In Mixed : both obstructive & restrictive occur at the same time.

EXTRA

Classification Of Ventilatory Abnormalities by Spirometry

	OBSTRUCTIVE	RESTRICTIVE	MIXED
FEV_1	↓	↓ or Normal	↓
FVC	↓ or Normal	↓	↓
FEV_1/FVC	↓	Normal or ↑	↓

COPD diagnosis

All of these indicate the use of Spirometry to diagnose COPD:

Symptoms

- **Cough**
- **Sputum production.**
- **Dyspnea**

Espousing to risk factors:

- **Tobacco.**
- **Occupation.**
- **Indoor/outdoor pollution.**

PHARMACOLOGY 435

PHARMAGOLOGY SIDE. Steroid medicines (corticosteroids):

How It Works?

Steroid medicines decrease inflammation in the airways (reducing swelling and mucus production), making breathing easier. And may be useful for asthmatic people.

Why It Is Used?

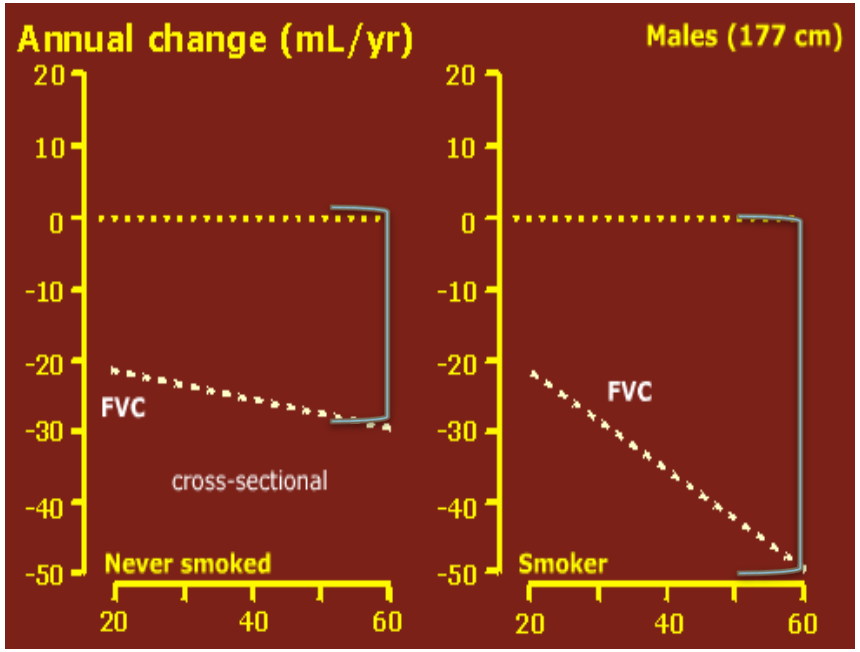
Oral steroid medicines may be used to treat chronic obstructive pulmonary disease (COPD) when symptoms rapidly get worse especially when there is increased mucus production.

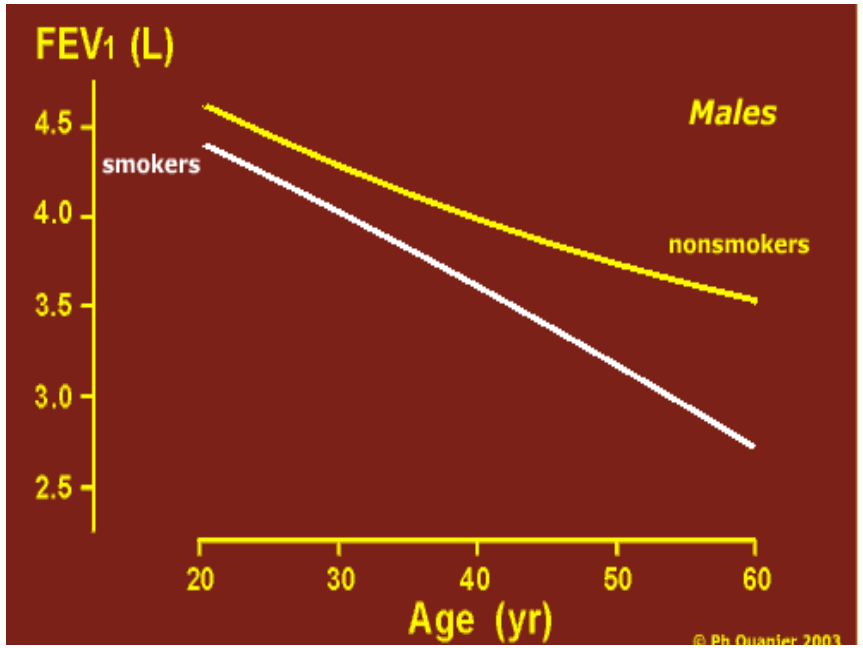
BOY'S NOTES

Smoking and spirometry

- For healthy **non-smokers** after the age of 30 the expected decline in Lung function parameter [FEV1] is 25–30 ml/ year.
- The average rate of decline of lung function in **smokers** as measured by Forced Expiratory Volume in 1 sec [FEV1] is 60-70 ml / year

Decreased around 25 – 30 ml/year.





Decreased around 60 - 70 ml/year.

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Videos

Dead space:
https://www.youtube.com/watch?v=KkoRTLeU0oc
COPD :
https://www.youtube.com/watch?v=5fFNGH4U6ml
Obstructive & Restrictive diseases:
https://www.youtube.com/watch?v=TOvYkSBzjjs

Quiz 1

https://www.onlineexambuilder.com/lecture-3/exam-56908

Quiz 2

https://www.onlineexambuilder.com/physiology-3rd/exam-57578

SAQ's Lec 4

An old lady was admitted to the hospital complaining from chest pain, and a spirometry was done to diagnose her problem.

A- The graph showed a decrease in volume, with no change in the flow. If no further tests are available, what would be your diagnosis?
A restrictive pulmonary disease.

B- The nurse repeats the test, turns out the graph shows the opposite. What would be your diagnosis?
An obstructive pulmonary disease.

C- If you was informed that the lady is a chronic smoker, what is the expected change in her FEV1 value?
60 to 70 m/L per year.

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Physiology Team

Leaders:

- Omar Alotaibi
- Samar Alotaibi

Girls members:

- Khawla Alammari
- Sara Alenezy
- Nouf Alrushaid
- Nouf Alabdulkarim
- Shadn Alomran
- Reem Alageel
- Nurah Alqahtani
- Malak Alsharif
- Ghaida Aljamili
- Monirah Alsaloli
- Lojain Alsiwat

Boys members:

- Rawaf Alrawaf
- Abdulaziz Alghanaym
- Abdulrahman Albarakah
- Abdullah Aljaafar
- Adel Alshihri
- Abdulmajeed Alotaibi
- Khalil Alduraibi
- Hassan Albeladi
- Omar Alshehri
- Abdulrahman Thekry
- Abdulaziz Alhammad

THANK YOU FOR CHECKING OUR WORK

For any correction, suggestion or any useful information,
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