3rd lecture

Respiratory ventilation

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OBJECTIVES

- Define the various lung volumes and capacities and provide typical values for each.
- Define ventilation rates, 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.

CONTENTS

COLOR INDEX:

- Red = important
- Grey = additional notes

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YOU DON'T HAVE TO MEMORIZE ANYTHING IN THIS PAGE , IT JUST GIVES YOU AN OVERALL IDEA ABOUT THE TEST AND ITS PROCEDURE :)

1- SPIROMETER AND CLINICAL TEST (INTRO) :

- **Spirometer:**

  Its an instrument used to measure Static volumes of the lung .

** Typically the patient is sitting and breathes into and out of the spirometer displacing a bell (diagram).

Clinical examination

The patient is asked to breath Normal quiet breathing that include inspiration and expiration.

Then, he is asked to take a deep breath –inspiration – followed by deep expiration. Now the deep inspiration is the inspiratory reserve volume, which is the additional volume above the tidal volume [1]..

The deep expiration is just bellow the tidal volume, Which is the air flow after deep expiration.

[1] The volume of air inspired or expired in a single breath during regular breathing. Also called tidal air.

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2- LUNG VOLUMES AND CAPACITIES:

- **Lung Volumes:**
  The lungs have <u>4 main volumes:</u>

Tidal volume (TV):	Is the volume of air inspired or expired with each normal breath Tidal volume = the volume of air that fills the <u>alveoli</u> + the volume of air that fills the <u>airway.</u>	≈ 500 ml
Inspiratory reserve (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.	≈ 3000 ml
Expiratory reserve (ERV):	Is the maximum extra volume of air that can be expired by forceful expiration after the end of a normal tidal expiration	≈ 1100 ml
Residual volume (RV):	Is the volume of air remaining in the lungs after the most forceful expiration	≈ 1200 ml

- **Lung Capacities (pulmonary capacities) :**

N.B : There are several lung capacities, <u>each lung capacity includes two or more</u> of the previous lung volumes.

Inspiratory capacity (IC)	Is the amount of air a person can breath in, beginning at the normal expiratory level (pose between cycles) 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.	$FRC = ERV + RV = 1100 + 1200 = 2300\ ml$
The vital capacity (VC)*	The maximum amount of air a person can expel from the lungs after filling the lungs to their maximum extent and then expiring to the maximum extent.	$TV + IRV + ERV = 500 + 3000 + 1100 = 4600\ ml$
The total lung capacity (TLC)	is the maximum volume to which the lungs can be expanded with the greatest possible effort	$TV + IRV + ERV + RV = 500 + 3000 + 1100 + 1200 = 5800ml$

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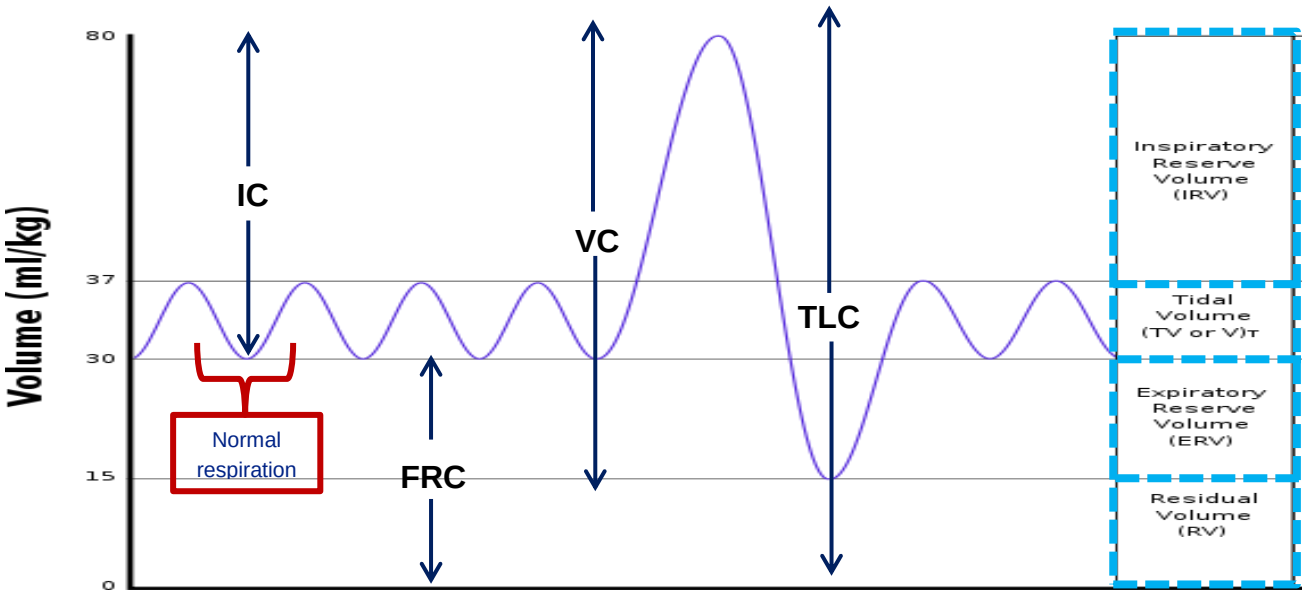


Note: spirometer is not capable of measure residual volume (RV), so it can't measure the total lung capacity (TLC) and the residual functional capacity (FRC).

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

** Closed circuit Helium Dilution Method :

((is a method used to determine FRC, RV, TLC))

The patient breathes known amounts of Helium "10%" , which has been added to the spirometer. We use the Helium gas because it is insoluble in the blood so our results will be accurate and we can use some mathematics After a few breaths the Helium concentration in the lung becomes equal to that in the spirometer. The amount of helium that was added and the lung concentration is used to calculate the lung volume through this equation:

Concentration of **He** in spirometry

$$C1xV1 = C2xV2$$

Volume of **spirometry** + FRC

Volume of air in the spirometry

Final concentration of He

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

3- FORCED VITAL CAPACITY AND FEV1

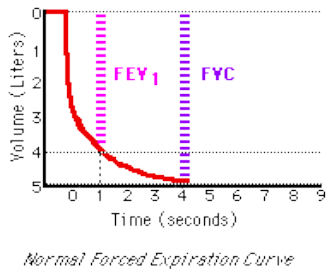
- **Forced Vital Capacity (FVC):**

We obtain it by asking the patient to Inspire as deeply as possible and then to breath out (Expire) as hard and as fast as he can (continued expiration) until he expired all the air out

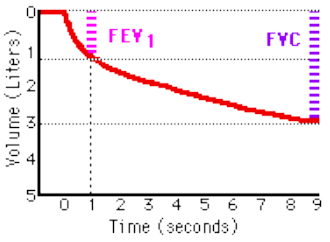
During this process the collected volume of air expired in the 1st sec is Known as Forced Expiratory Volume in 1st second (FEV1)

- The normal FEV1/FVC Ratio is **80%** and it **differentiate between Obstructive and Restrictive lung diseases** !

Obstructive Ventilatory Defect (**The ratio ↓**)

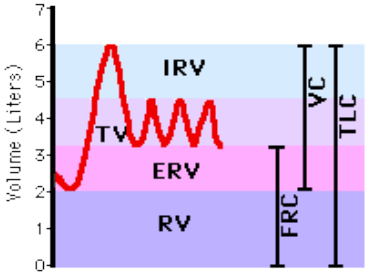


Normal Forced Expiration Curve

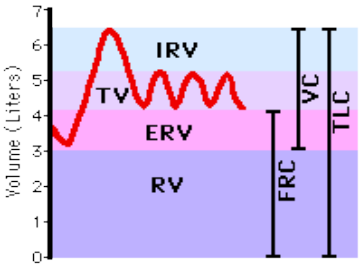


Obstructive Forced Expiration Curve

(e.g. Bronchial asthma, Emphysema)

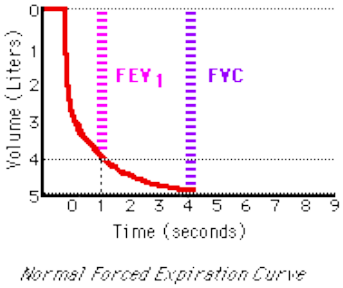


Normal Spirogram

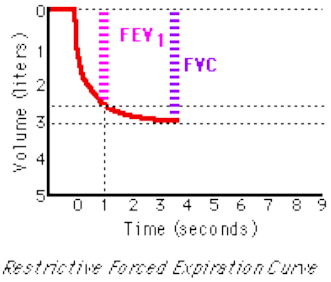


Obstructive Spirogram

Restrictive Ventilatory Defect (The **ratio is normal**)



Normal Forced Expiration Curve



Restrictive Forced Expiration Curve

(eg. Interstitial Pulmonary Fibrosis)

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- **Minute Respiratory Volume (MRV) :**

MRV (**Minute Respiratory Volume**) = RR (**Respiratory Rate**) X TV (**Tidal Volume**)

$$12 \times 500 = 6\ L/min.$$

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.

4- DEAD SPACE AND ITS EFFECT ON ALVEOLAR VENTILATION

Anatomical Dead Space	Physiological Dead Space
is the volume of air present in the conductive part of the respiratory passages = 150 ml.	**Is when the alveolar dead space is included with the anatomical** ** equal zero in normal healthy person

when some of the alveoli are non-functioning or partially functioning (due to absent or poor blood flow)

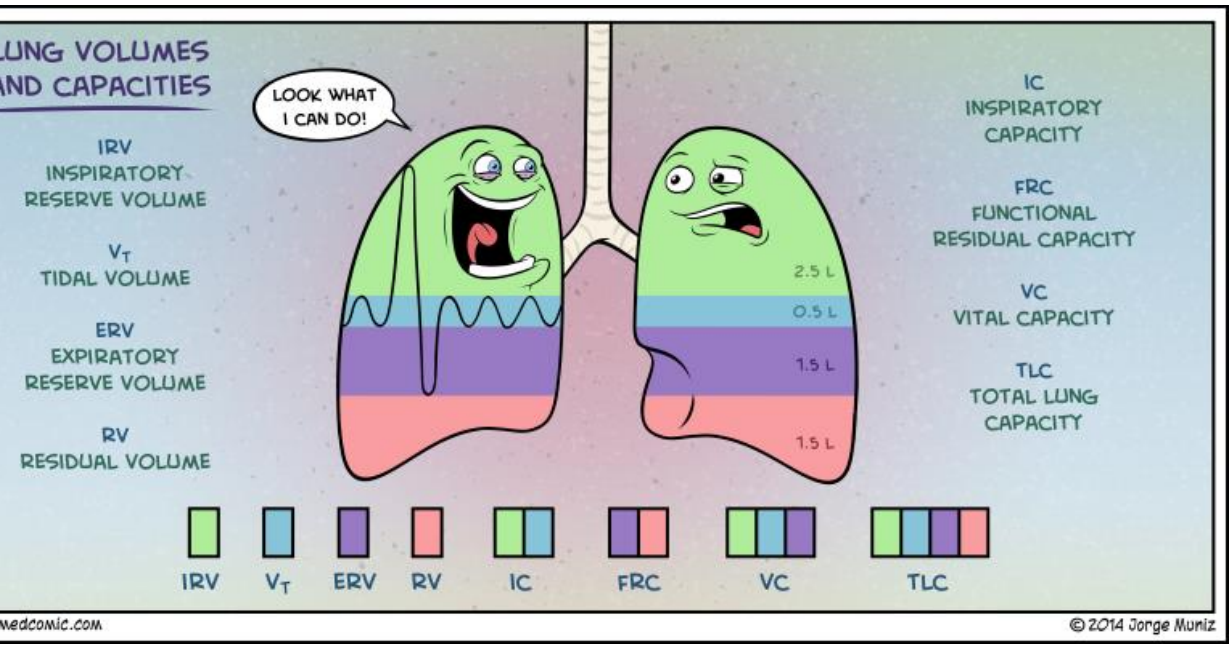
5- ALVEOLAR VENTILATION

- **Rate of alveolar ventilation per min:**

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

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

$$= (500 - 150) \times 12$$
$$= 12 \times 350$$
$$= 4200\ ml/min$$



Check your understanding

Respiration-ventilation 3d medical animation

Lung Volumes and Capacities

Obstructive Vs Restrictive Lung Diseases

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