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First of all, this is my first sheet so excuse any mistakes I might make and let's start:

As we said before in our last lecture about lung capacities and lung volumes, we have:

1- **Tidal volume**: which is how much air we breathe in or out in normal conditions (about 0.5 liters)
2- **Inspiratory reserved volume**: which is how much more air we can inspire after our normal inspiration (tidal volume)
3- **Expiratory reserved volume**: which is how much air we can expire after normal expiration (tidal volume)
4- **Functional residual volume**: which is how much air is stayed in our lungs after normal expiration
5- **Residual volume**: is how much air is left in our lungs after maximum expiration (about 1.2 liters)

1- **Vital capacity**: which is maximum air we can expire after maximum inspiration
2- **Inspiratory capacity**: which is the maximum amount of air we can inspire (tv + irv)
3- **Total lung volume**: which is the total amount of air in the lung after maximum inspiration (includes the residual volume)
4- **Forced expiratory volume** (FEV1): which is the amount of air forced out in the first second of vital capacity

Most of these volumes and capacities can be measured by what we call **spirometer** (as you see in slide 3), but the picture is showing an old school spirometer, the new spirometers don’t have the water tube.

In the spirometer in the picture we have the water tube in the middle, the mouth piece is connected to what we can the drum, and in the far left we have the recorder.

The nose piece stops us from inhaling atmospheric air through the nose, because we only want the patient to breathe through the mouth piece which is connected to the drum.

In the new system of spirometers, we don’t have this complicated system, we take air from atmosphere and then expire through the mouth piece and the machine will measure the results, but we still use the nose piece.

In slide 4 we have a **spirogram**

**TV** = Tidal volume (500ml)

**IRV** = Inspiratory reserve volume (3,000 ml) (from the end of inspiration to end of maximum inspiration)

**IC** = Inspiratory capacity (3,500 ml) (TV + IRV)

**ERV** = Expiratory reserve volume (1,000 ml)

**RV** = Residual volume (1,200 ml) (FRC – ERV)

**FRC** = Functional residual capacity (2,200 ml) (RV + ERV)
VC = Vital capacity (4,500 ml) (IRV + ERV + TV) or (IC + ERV)
TLC = Total lung capacity (5,700 ml) (VT + RV)

RV and FRC can't be measured by spirometer

We do all these measurements to assess if the lung is functioning properly or there is something wrong (disease or anything) and we call it lung function test.

Slide 5 he just read it:

Spirometry:
- Volumes:
  - T.V = 500 ml
  - IRV = 3000 ml
  - ERV = 1000 ml
  - R.V = 1200 ml

- Capacities:
  - IC = T.V + IRV 3500 ml
  - FRC = ERV + R.V 2200 ml
  - V.C = IRV + TV + ERV 4500 ml
  - TLC 5700 ml

Slide 6:

Functional residual capacity: the air which stays in the lungs after normal expiration

As we said we can't measure it by spirometer, but we can measure it by a mixture of helium (helium dilution method)

The formula for measuring FRD =((CiHe/CfHe) - 1) * Vi spir.

So, we need to know the initial concentration of helium, the final concentration of helium, and the initial volume of air in spirometer to measure thee FRD.

We already know the initial volume and concentration, so all we need now is the final concentration, how do we find it?

After we put a known concentration of helium and volume of air in the spirometer, we ask the patient to expire normally (not maximum expiration) so the lungs now will only have FRC left

Then we tell the patient to breathe from the spirometer which has the known concentration and volume

After the patient starts breathing, the helium will be mixed with the FRC air, so this will lead do dilution of the helium with the FRC
After that we measure the concentration of helium (final concentration) and we use it in the formula to find the FRC.

After we have found the FRC we can easily calculate the residual volume (RV), which is the formula:

\[ \text{RV} = (\text{FRC} - \text{ERV}) \]

And this is how we calculate FRC and RV using the helium dilution method.

A student asked a question and the record isn’t very clear about it from min 13-15.

Now, the tidal volume (the air we inspire or expire normally which is about .5 liters) not all of it reaches the lungs, some of it will stay in the respiratory tract (between the nose, mouth, larynx, trachea, bronchi, bronchioles……. Until alveolar ducts) and this is called dead space or anatomical dead space, which is not involved in exchange.

So, part of the tidal volume (0.5 l) is dead space, which is about 150 ml, or .15 L and this dead space volume is influenced by the size or length of the person, but we still say it’s around 150 ml.

*How much air is actually involved in exchange from tidal volume? 500 ml – 150 ml (dead space) = 350 ml

Now we have something called **pulmonary ventilation** (like cardiac output): which is the amount of air we inspire or expire each minute.

**Pulmonary ventilation =** tidal volume x respiratory rate (about 12) = .5 L x 12 = 6 L per minute

now we have something else called **alveolar ventilation:** which is how much air we inspire or expire each minute that is involved in exchange.

**Alveolar ventilation =** (tidal volume – dead space) x respiratory rate = (.5 – .15)L x 12 = 4.2 L/min

Slide 7:

A diagram showing alveolar space (in gray) and dead space (respiratory tract) (in blue means fresh air) during inspiration.

After inspiration the dead space will be filled with atmospheric air (mainly oxygen), but after expiration the dead space will be filled with alveolar air.

So, if we want to examine the alveolar air (in other words concentration of alveolar air or composition of alveolar air), what kind of sample will we take? From which part of expiration?? We will take from the last part of expiration which is called **end tidal volume**.

So, as we said after inspiration dead space is filled with atmospheric air, but after expiration filled with alveolar air, and if we need to examine the alveolar air we don’t have to take air directly from alveoli we will take it from the **end tidal volume**.
Slide 8:
A diagram similar to slide 7 but this is during expiration

Slide 9: the doctor didn’t explain much about it neither slide 8 or 7 he just read what’s in the slides so go back and look at them and look where the fresh air is during inspiration or expiration and so on, very easy won't take more than a 5-10 mins from you don’t skip looking at them.

So now what we wanna talk about is how we measure the dead space?

First, we ask the patient to take a deep breathe from pure oxygen (O₂) now the dead space is filled with pure air too

Then we tell them to expire in a **nitrogen meter**

As we observe the nitrogen meter, as we know that the dead space is filled with pure O₂ which has no nitrogen, so after the air in the dead space is all out, the air from the alveoli which has nitrogen reaches the nitrogen meter and we start to get a reading, when we start getting a reading on the nitrogen meter this indicates the end of the dead space air.

So, in other words as we start to observe nitrogen this is the end of dead space volume.

A STUDENT asked why do we use nitrogen not CO₂, even though CO₂ is at higher concentrations than nitrogen?? the doctor answered you can actually use CO₂, but nitrogen is a noble gas, so it will be more accurate to use nitrogen.

Another STUDENT asked from where does nitrogen come if we inhaled pure oxygen?? The doctor said we have nitrogen in our alveoli

Another question but it’s not hearable........ (min 27) but during the answer the doctor said there is special equipment to measure this kind of stuff like: oxygen meter, co₂ meter, mass spectrum meter.

Another question: the dead space air stays inside? Doesn’t change? The doctor said no its actually changed every time we take breathe

*dead space air is the first to get in during inspiration and first to get out during expiration

**We measure the dead space to know how good the exchange is at the level of alveoli because it helps us know the exact amount of air that reached the alveoli and was available for exchange.**

A question:

If the dead space is 150ml, and our tidal volume was 150, how will air reach alveoli? The doctor said there is no way that the tidal volume will be 150, even when we have disease it will decrease but not to 150, it might get to 200-250 but it will never be less than the dead space and he said the tidal volume is increased in athletes
And he said even in very severe disease, where the tidal volume is very low and respiratory rate is very high, this won’t happen, why? Because not all the air in the dead space will be exhaled because of rapid respiratory rate and these patients will be in intensive care (العناية المركزة)

Before I end these is something in the slides called physiological dead space, which is different form anatomical dead space, the doctor didn’t mention it

**Physiological dead space** = anatomical dead space + alveolar dead space

Which means the anatomical dead space is only the dead space which is confined to the respiratory pathways, but the physiological also involves any alveoli that have poor perfusion of blood, so it doesn’t exchange sufficiently, this is just a humble understanding of what I read from a website

And this is the end for pulmonary ventilation, volumes, capacities, tests and everything and now we will begin with the pulmonary circulation (min 35)

**Anatomy of blood to lung:**

Right atrium → right ventricle → pulmonary artery → its 2 branches → small arteries → Arterioles → capillaries

If you remember we said in CVS anything that happens on the right side happens on the left side (cardiac output, venous return), with the exception that the pressure is much lower in the right side (pulmonary resistance is 14% of the systematic)

Why do we have this pressure difference? Because of the difference in the resistance (pulmonary resistance is low, systemic resistance if high)

**Anatomy of blood from the lungs:**

Pulmonary veins → left atrium → left ventricle → blood circulation

Goodluckk to all, best of wishes in this system