* We can express O2 in our bodies in three different ways:
1. By the concept of partial pressure of oxygen in a mixture of gases (PO2).
2. The concentration of oxygen, which means how much O2 in the blood.
3. (O2-Sat): the saturation of oxygen, which means how much O2 is bound to HB.
* The concentration of oxygen is the most efficient and important way, we don’t care if PO2 and (O2-Sat) are normal if we have a problem with the concentration of O2. (الدكتور حكى المعلومة بشعبة 2 بس ما سمعتها بالريكورد)
* We are going to start talking about the first way of expressing O2 which is **Partial Pressure of O2:**

In a mixture of gases, each gas behaves as it’s the only gas available in the mixture; this is **the concept of partial pressure.**

So if we have a mixture of O2 and CO2, and the O2 pressure outside is more than inside, then O2 will only enter the inside regardless the CO2 pressure.

 At sea level the atmospheric pressure equal to 760mmHg, if I told you that 21% of them are O2 and 78% is N2 then:

PO2 at sea level= 21% \* 760= 160mmHg

PN2 at sea level= 78%\* 760= 600mmHg

PCO2 at sea level= Zero

PH2O at sea level= Zero (consider it as dry atmospheric pressure)

* So now the four gases have a total of 760mmHg, if the atmosphere is not dry (humid) then the value of PH20 (g) is almost equal to 30mmHg, this value is going to replace the other two gases(O2,N2) according to their ratio this is the case when air enters the airways because the goblet cells of respiratory epithelium secrete mucus, the mucus will add water vapor to the air thus the dry atmospheric air becomes humidified atmospheric air in the **anatomic dead space**.
* Now let's see what is the anatomic dead space?

Trachea is the main tube in the respiratory system, it divides into two primary bronchus then into secondary and tertiary bronchi respectively, division starts from trachea so we will consider it as (division 0) or (generation 0) then we have another 23 generation along the lung, we call the first 16 generations (from 1-16) **the conducting air ways or anatomic dead space,** why?

Because inside this zone there’s no gas exchange, it’s function is just to conduct air in and out.

The volume of the anatomic dead space (ADS) = 2ml/kg \* body weight

If a 75kg male, ADS= 2ml/kg \* 75= 150ml

Then **the anatomic dead space (ADS) = 150ml**

So the volume of air from the mouth and trachea to the end of generation#16 is 150ml and this air doesn’t participate in gas exchange.

The last 7 generations (from 17-23) are called the respiratory zone.

You have to know:

* Generation #1 is primary bronchus.
* Generation #16 is terminal bronchiole.
* Generation #17 is respiratory bronchiole.
* Generation 23 is alveoli.

The anatomic dead space has respiratory epithelium with many functions:

* The cells have cilia with a skeletal mechanism, so they can take the mucus out toward the larynx with the sputum.
* It adds water vapor (H2O) to the dry air, this means we have 3 gases in the anatomic dead space instead of 2 gases in the outside air.

PH2O= 47mmHg (at 37 C°) When fully humidified and saturated,

The atmospheric pressure equal to 760mmHg doesn’t matter how many gases there, so any extra gas will be at the expense of the previous existed gases.

So when we add H2O we doesn’t add 47mmHg over the 760mmHg, instead the PH2O will be part of the 760mmHg

760-47=713mmHG, (those 713mmHg includes PO2+PN2)

PO2 in the ADS= 713mmHg \*21%= 150

Then the PN2 in the ADS = 760 (the total pressure) – (47+150) =663mmHg, or

PN2= 713\*78%=663mmHg

* **In the alveoli** there are 4 gases with one new gas is entering which is CO2,

PAO2 (the letter A here means alveoli) =100mmHg, decrease because O2 start to diffuse to the capillaries in this zone.

PACO2=40mmHg

PAH2O=47mmHg (constant temperature throughout the body= 37 C°)

PAN2=760-(40+47+100) =573mmHg

You have to know:

* **PA,** the partial pressure in the alveoli
* **Pa**, the partial pressure in the arteries
* **Pv**, the partial pressure in the venous
* Pv , the partial pressure of the mixed venous
* **Pe**, the partial pressure in the exhaled air
* **Pe** , the partial pressure in the mixed exhaled pressure

**Conclusion:**

* PO2 outside = 160, PCO2 outside= 0
* PO2 in ADS = 150, PCO2 in ADS = 0
* PO2 in alveoli = 100, PCO2 in alveoli = 40

🡪From now on, we are only going to talk about PO2 and PCO2 because PH2O(g) is constant throughout the body since the temp. is not changing and the PN2 is not important because N2 is just a spectator molecule it has nothing to do with gaseous exchange.

* The blood comes from the right heart with PvO2=40mmHg, this number is small compared to PAO2=100mmHg, also the lung volume (2.2L) is larger than blood volume which touches the lung (70ml) with constantly incoming fresh air, these factors makes O2 diffuse from the alveoli to the blood makes its PO2=100mmHg as same as the alveoli, this happen before the blood reaches the end of the first third of the capillary, then the blood continue as arterial blood to the heart and the whole body

Conclusion: PaO2= 100mmHg

Let’s talk about CO2, PvCO2=45mmHg and we know that PACO2=40mmHg, this makes CO2 diffuse from the capillary toward the alveoli in contrast to the O2 diffusion.

🡪The CO2 diffusion is 20 times easier than O2 diffusion, which means that if we have lung disease, most probably O2 is affected before CO2 meaning that if we did a test we can find a patient with a normal CO2 although he has a lung disease (abnormal O2), however if we find both gases are abnormal then there is too much destruction.

* **The Arterial Blood Gases (ABG)** normal values are when PaO2= 100mmHg and PACO2=40mmHg, we have to test the ABG for any patient, the pulse occimeter give you an indirect image about the ABG.

**Distribution of gases in different compartments:**

🡪After blood becomes saturated with O2, it goes from the lung to other parts of the body with PaO2=100mmHg in the capillaries, and the PO2 for the interstitial is 40mmHg, the difference in pressure allow the diffusion from the capillary to the interstitial makes them both 40mmHg, and another factor for diffusion from capillary to interstitial is diff. in volume; interstitial volume (11L) much bigger than the capillaries (0.35L).

🡪In the cell the PO2 should be less than 40mmHg to allow diffusion from the interstitial to the cell, PO2 differs from cell to another; it may reach 1 or 2mmHg according to the cell activity, then the blood return to the veins with PvO2=40mmHg.

🡪PaCO2 in the interstitial is 45mmHg while it’s 40 in the artery, this allow its diffusion toward the capillary, but in the cell it should be more than 45mmHg to be able to go outside the cell toward the interstitial.

\*\*Now, why the ABG is important to us while we don’t care about the venous blood gases?

Because the blood gases in the arteries comes from one source which is the pulmonary veins then the left atrium then the left ventricle to the whole body, while the blood gases in the veins comes from all over the body toward the pulmonary artery through the right atrium, each vein has a different PO2 and PCO2 according to the cells activity, and that’s why we call the blood in the pulmonary artery mixed venous blood.

The interstitial PO2 is 40mmHg, how could reach higher value like 50 or95mmHg, how can we manipulate this value?

By two ways:

* Decrease the consumption of O2 from the cell, like inactive cell or
* If the cell activity is normal, increase the blood flow toward these cells, so the cell takes its need and the rest will remain in the interstitial making the PO2 high due to the additional amount of the blood.

To make it clear if we have 3 people the first is giving to the second 4 sandwiches and the 2nd takes one and gives the rest to the the 3rd person in this way the 2nd person consumed 25% of sandwiches but if the first person gives 100 sandwiches to the second and the second also only takes one and gave 99 sandwiches to the 3rd then the 2nd person only consumed 1%, the same thing is happening in the blood if interstial is loaded with blood then the cell will take what it needs and the rest is going to remain in the interstial in this case PO2 is will increase.

* **CPR: Cardiopulmonary Resuscitation (mouth to mouth breathing)**

First you have to know the term **Tidal volume** which is the amount of air we exhale or inhale, which equal (0.5L).

CPR is when we give the patient our exhaled air. When we blow air inside the patient's body we actually blow an exhaled air which has less oxygen. So when we first blow air we give him 500ml, 150ml of the anatomic dead space, this is the 1st portion. The 2nd portion is the 350ml which will be alveolar air. The first 150ml were given had PO2= 150mmHg while the 350ml had PO2=100mmHg, in total we gave the patient 500ml. To know the PO2 we actually supplied:

PeO2= =116mmHg O2

PeO2=116mmHg…This is a significant amount of O2.

For the PCO2, the first 150ml we gave the patient had PCO2= 0, and the 350ml had PCO2= 40mmHg. And now we can calculate how much PCO2 we gave the patient as follow:

PeCO2

Q) Why did we use mixed exhaled air (Pe)?

This is because the 1st portion of air has a different composition of gases than the second, the first portion is considered as fresh air but it's humidified.

* The main law in physiology is Ohm's law: Flow=Driving force / Resistance

In the respiratory system: F= ΔP/ ΔR

The flow in this case is the inspiration and expiration of air.

When the atmospheric pressure is 760mmHg we will consider (Patm) equal to Zero.

If the outside pressure and the (ADS) pressure and the alveolar pressure is Zero then ΔP is Zero, thus there’s no driving force then there’s no flow (breathing).

To induce the flow (breathing) we have to make the outside pressure more than the alveolar one or make the alveolar pressure less than the outside one, normally we can’t manipulate the outside pressure every time we breath, so the only way is by manipulation intra-alveolar pressure by making the alveolar pressure (-1) this equal to 759mmHg and this starts a driving force to start the flow of air.

The driving force we need to inhale or exhale 0.5L of air (the tidal volume) so small, 1mmHg enough, while in the cardiovascular system we need 100mmHg to drive blood from arterial system toward the vena cava, why?

Because the airway resistance is very small compared with vascular resistance (100 times more) although both systems driving almost the same amount of air or blood in one minute (5L).

According to Boyle's law we change alveolar pressure: volume is reversely proportional to the pressure, the more the volume the less the pressure and vice versa for the same number of molecules.

What actually happens is that we decrease the pressure around the lung by increasing its volume, how we do this?

Our lungs are situated in such a closed box (the thoracic cavity) with a movable floor (the diaphragm), when the diaphragm contract the abdominal cavity move downward, makes more pressure on the vessels to drive the blood toward the heart (venous return), also the thoracic cavity increase in volume while the pressure around the lung becomes more negative (from-4 to -6), this is called an inflation pressure allowing the lung to expand, notice that the intrapulmonary pressure also becomes negative (subatmospheric) this will drive air in.

Conclusion: ***THE INFLATED LUNG DRIVES AIR IN, IT IS NOT THE AIR EHICHINFLATE THE LUNG.***

The normal physiological breathing pressure is negative, which meets the contraction of the diaphragm (active), in exhale there’s relaxation of the diaphragm (passive).

If the diaphragm doesn’t function, we use a machine called respirator or ventilator, we induce a tube inside the trachea which is connected to the respirator, the respirator changes the outside pressure to become positive then air drive in, then the pressure of respirator becomes negative to drive air out.

The artificial breathing pressure is positive in contrast with the normal breathing.

***Dedicated to all my colleagues except Mahmoud Qaisi***

 