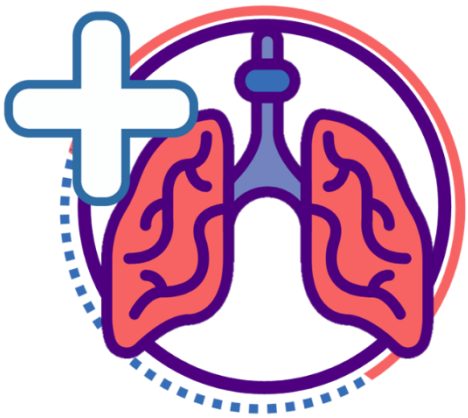

RESPIRATORY SYSTEM

Physiology

Sheet Slide

Number:	- 1
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I highly recommend watching the lecture before reading this sheet as it will be the same as the illustrations mentioned by the doctor.

- RS and CVS systems are highly interconnected, as a fact if you have a lung disease you probably will develop heart failure and vice versa; for example : left heart failure will result in pulmonary edema and decreased O2 supplied by the lung due to lung disease will result in right heart failure.
- The right ventricle eject the blood through the pulmonary artery to the pulmonary capillaries to pick up O2 and give away CO2, then the oxygenated blood will come back to the heart through the pulmonary veins and it will be ejected by the left ventricle as arterial blood.
- As we know, the space between the cells and the systemic capillaries is called interstitium, so for O2 to diffuse into the interstitium, the partial pressure in the blood must be more than the interstitium then to the cells according to pressure difference also.
- CO2 diffuses in the other way around as PCO2 in cells is higher than PCO2 in the interstitium.
- The end result is the utilization of O2 by the mitochondria; if this utilization is decreased it's called **Hypoxia**.
- We need the oxygen inside the mitochondria in the electron transport chain to generate ATP.
- If O2 is present then the cell will generate 36 ATP, if not it will generate only 2 ATP (anaerobic respiration).
- There are many respiratory chain enzymes and the final electron acceptor in the mitochondria is O2.
- At the sea level where atmospheric pressure= 760 mmHg the air composition is :
  *21% O2 & PO2= 160mmHg
  *79% N2 & PN2= 600mmHg
  * PCO2=0.3 mmHg (almost zero)
- At the height of 5.5 Km the pressure drops to the half:
  *atm= 380 mmHg, PO2= 80 mmHg, PN2= 300 mmHg
- At 11 km height :
  *atm= 190 mmHg, PO2= 40 mmHg, PN2= 150 mmHg
- Hypoxia has 4 types:
  Hypoxic hypoxia (decreased O2 in the outside air), Stagnant hypoxia (due to blood obstruction), Anaemic hypoxia (haemoglobin is there

but it's occupied by another gas), histotoxic hypoxia (the mitochondria aren't able to use O2 although O2 is available, like in septicaemia where the toxins poison the mitochondrial chain, or like cyanide poisoning).

- RS can be considered as a tube, this tube has two parts: a bronchial tree (airway) and a balloon ending (lungs).
- Normally we have 300-600 million alveoli (that has three kinds of cells: **thin squamous cells** that are appropriate for gas exchange, **columnar cells** that produce surfactant and **alveolar macrophages** that clean any foreign body in the alveoli).
- If the tube is patent (not obstructed), air leaves with no difficulty as airway resistance is very small.
- If an obstruction occurs, the diameter of the tube will become narrower and resistance (R) will increase as it is inversely related to the diameter (r) (or we could say the cross sectional area), for example, if r is decreased slightly, R will increase highly.

- As we said before hypoxia is decreased O2 utilization by the cells and its potential causes are:

1) Oxygen isn't available in the air such as at high altitudes.
2) Increased airways' resistance as 70% of lung diseases are of obstructive pattern (ex: COPDs as emphysema, bronchitis and some forms of asthma).

- Airways may be not patent and become narrower thus resistance is increased significantly.

3) Balloon (lung) incompliance, as it must be compliant (meaning that a small force is needed to inflate this balloon, if much force is needed then this is called incompliance).

- Inflating a lung is hundred times easier than a child balloon, so if the lungs become incompliant (unstretchable, rigid, collapsed) then it will cause restricted pulmonary diseases (20-25% of lung diseases are of this pattern), such as: fibrosis and RDS (respiratory distress syndrome).

4) Problems in the respiratory membrane.

- Each alveolus is surrounded by a huge network of capillaries that function to exchange gases.

- Between the capillaries and the lungs there is interstitium.

- The oxygen has to diffuse through the 6 layers of the respiratory membrane:

1. Surfactant (surface acting agent)
2. Alveolar epithelium.
3. Basement membrane of alveoli.
4. Interstitium.
5. Basement membrane of capillary.
6. Endothelium

- You need to know that O2 can cross this membrane and any other biological membrane as this membrane doesn't exist, so O2 supply to the cells is not diffusion limited. However, CO2 crosses the membranes 20 times easier than oxygen because it's 20 times more soluble than oxygen.

- So when there is a lung disease the first to be affected is the O2, as in Type 1 respiratory failure, the PO2 in blood is below 60 mmHg and PCO2=40 (normal), while in type 2 PO2 is below 50 and PCO2 is above 50mmhg .

- The diffusion becomes limited if the membrane is thickened as in pulmonary edema, pneumonia, TB, fibrosis, infiltration of the interstitium, so the more the thickness, the less the diffusion.

Side note: in cases of thickening of the respiratory membrane it will be difficult for the lung to achieve full oxygenation of the blood coming from the pulmonary artery so the PO2 in the blood will be less than normal.

- As we said before, the right ventricle ejects the blood through the semilunar valve to go to the pulmonary artery, and for this to happen, the pressure in the right ventricle must exceed the pulmonary artery pressure.
- The pressure in the pulmonary artery is 14 (this is the mean pressure) this pressure is called the afterload > the pressure that the right ventricle has to overcome to eject the blood. If this pressure becomes

24 for example, the Rt. Ventricular pressure must become 25 to eject the blood, if 34 then the ventricular pressure must be 35 and so on. Eventually, this will lead to failure of the Rt. ventricle, that's why any pulmonary hypertension will result in right ventricular failure.

- The pressure in the pulmonary capillaries is 7 mmHg (which is very little) as in the lung there is no need for filtration (Dry lung), while the systemic pressure is 30 & the glomerular capillaries' pressure=60 mmHg (needed for the huge filtration in the kidneys).
- **Side note**: The small pulmonary capillaries' pressure is needed to prevent pulmonary edema that can kill a person within 2 hours, that's why the lungs are filled with lymphatics that drain in the right lymphatic duct mainly and little will drain in the thoracic duct.
- If some capillaries are destroyed for any reason, then the resistance will increase. (For example if you have 5 capillaries and three of them were destroyed, the same amount of blood will flow in the remaining two thus the resistance will be higher).
  According to Ohm's low (**F= ΔP/R),** the flow is directly proportional to the driving force (pressure difference) and inversely proportional to resistance which is the pulmonary vascular resistance.
- So, if the pressure in the pulmonary artery increased 5 times for example (14*5=70 mmHg), the right ventricle will dilate and eventually will fail.
  Cor pulmonale: it's the right ventricular dilatation that may result from pulmonary hypertension and can lead to Rt.ventricular failure

* Continuing with the potential causes of hypoxia:

5) cardio-vascular problems (problems in the heart, vessels or in the blood)

6) Respiratory muscles' problems, mainly the diaphragm, whether these problems are due to contraction or excitation.

7) Hypoxia could be due to polio infection, it can cause paralysis of the diaphragm or it could be due to suppression of respiratory centers by anesthesia or drug overdose as it inhibits the respiratory cells causing respiratory arrest.

* The doctor stated that he is going to discuss each one of these causes one a lecture.

- The RS is composed of airways starting from trachea, trachea will divide into Rt. & Lt. Primary bronchi and these primary bronchi will divide into secondary bronchi and the secondary will divide into tertiary, until we reach 23 divisions (number 23 is the bulb like alveoli, number 0 is the trachea).
- From (1-16) they're called the conducting zone as the air goes in and out with no gas exchange (NO.16 is called the terminal bronchiole).
- From (17-23) they're called respiratory zone, gas exchange takes place in this zone mainly in the 23rd division which are the alveoli (NO.17 is called respiratory bronchiole).
- This dividing structure is called Bronchial Tree.

- The air passes through the nose to the pharynx then the larynx, to the trachea, to the 1st 16 generations (all of the previous is called anatomical dead space, because there is no gas exchange through them).
- The volume of this dead anatomical space is 2ml/Kg, so if a person with 75Kg body weight he will have 150 ml of air inside the dead space. If he inspires 500 ml of air, 150 of it will stay in this dead space and the other 350 will continue to the other divisions where gas exchange takes place.
- The same as we took in the CVS (CO=HR*SV)

Respiratory (alveolar) minute ventilation = Respiratory rate * Alveolar air

4.2L = 4200ml = 12 * 350

Best of luck and sorry for any mistake :")