Human Physiology
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Week - 04
Lecture - 01

Hello everyone, welcome to another new class in human physiology. So, this week we will start with the lung. So, we will see what the anatomy of the lung is, what the different components of the lung are, and we will also thoroughly discuss their functions; finally, we will cover different lung-related diseases. So, let us start with it in this class; first, we will discuss the lung anatomy and its functions. So, what different content will be covered in this class? So, we will briefly discuss the overall respiratory system of our body, then we will discuss the anatomy of the lungs, and we will discuss the different lobes and features of the lungs. And then we will see what the structural components of the lung are, for example, alveoli, bronchi, and the bronchial tree, and then we will also discuss the role of surfactant and the different types of cells that are present in the lung.

So, the lung is a very important component and organ for our life because, as we all know, through the lungs, we can consume oxygen, which is highly important for the cellular respiration process. And also, like using oxygen, energy is being produced, which is consumed for various types of physiological processes, including growth, movement, tissue regeneration, proliferation, repair, etc. And also, during the cellular respiration process, oxygen is consumed, and basically, after metabolic activity, a lot of carbon dioxide is released, which our lungs help to remove from our body. So, in this way, some of the toxic substances, for example, carbon dioxide, can be removed, and oxygen, which is required all the time for regular metabolic activity and the respiration process, is consumed by the lungs.

So, as you know, air is taken into the lungs where oxygen is absorbed. Do you know that the average human breathes about 20,000 times per day? So, you can imagine that it is a kind of low frequency, or almost like a high frequency, that the number of breaths is so high. So, as we see, the lung is a pair of respiratory organs that are situated inside the thoracic cavity. So, if you remember, we discussed different cavities inside our human body, and in the belly area, we said it was the intraperitoneal cavity, and just above the intraperitoneal cavity, inside the rib cage or just near the rib cage, we have the thoracic cavity. And inside this thoracic cavity, we can see that there are two pairs of lobes, one pair of lobes, and this is called a lung.

So, this is basically a respiratory organ, as we already said, and each lung innervates the corresponding pleural cavity. So, the young lung is generally a little bit brownish-green in color, but as it grows, like the atmospheric carbon slowly gets deposited in the lung, it becomes more dark gray or black. The right lung generally weighs about 700 grams and is mostly around 50 to 100 grams heavier than the left lung. So, basically, the right lung is a little bit heavier compared to the left lung. Then, as you see, in the right lung, there are mostly three lobes.

You can see the image here: one is the superior lobe, then the middle lobe, and the inferior lobe. In between the lobes, there are two fissures. You can see the two divisions, or fissures, here: one over here and the second over here. And all these lobes and fissures basically create different components or different parts of the right lung, for example, apical, posterior, anterior, lateral, medial, and anterior basal. In the left lung, there are only two lobes, while in the right lung, as we discussed, there are three lobes; in the left lung, there is the superior lobe and the inferior lobe.

And in between the two lobes, there is only one fissure; you can see here one separation present in the right lung and in the left lung. And this left lung, using these different lobes and the fissures, has certain components or places that can be designated as the apical region, anterior region, superior region, inferior region, and anterior basal region. So, as you can see, the gross anatomy of the lung basically has thyroid cartilage, and below it we have what is like the tracheal cartilage. So, the lungs are mostly like a pair of spongy, air-filled organs, located on both sides of the thorax. So, as you can see inside the thoracic cavity, these two spongy organs on both sides, right and left, mostly consume a lot of oxygen.

And now, if you carefully check the overall anatomy, we have this tracheal cartilage, which is also called the windpipe. So, this tracheal cartilage, which is also called the windpipe, mostly conducts inhalation and exhalation. Through the tracheal cartilage, we inhale air. And now this tracheal cartilage is divided into the right bronchus and the left bronchus. So, you can see the tracheal cartilage is divided into the right bronchus and the left bronchus.

This right and left bronchus further branch. For example, like a lot of bronchioles, and eventually, as you can see, these small bronchioles, which eventually become the right and left bronchus, are extensively branched, and these are basically small epithelial or alveolar cells where oxygen can be consumed. Interestingly, a thin layer of fluid that is like a kind of lubricant, which is also present in the lungs, helps the lungs to expand or contract smoothly. So, inside the lung we have a lot of surfactant and lubricant that help basically for the lung in terms of their smooth movement because in cases of a lot of friction, the small alveolar cells or the lung cells can get damaged or lose their capacity for oxygen storage. So, alveoli, as you see, are like the bronchioles and eventually end in a cluster of microscopic air sacs.

So, these are called alveoli, and in the alveoli, as we said, oxygen from the air can be absorbed into the blood because a lot of blood vessels are also present in the alveoli. So, directly like these oxygens which can be absorbed from the lungs using the process of absorption and also hemoglobin binding inside our blood, they can eventually go to the blood circulation. So, this is the place where oxygen eventually comes out of the gas and goes to the liquid like blood and gets transported across different cells and organs in our body. Carbon dioxide, which is like a waste product after metabolism, can also basically travel. So, from our tissues, once they perform the metabolic function, they can also release carbon dioxide, which can eventually be exhaled through the alveoli.

Between the alveoli, there is a thin layer of cells that is also called interstitium. This contains the blood vessels, and as you know, these cells support the alveoli in terms of oxygen consumption in the blood. So, you can see that a lot of blood vessels are present near the alveoli for the eventual respiration process. Then, as you see, it is like the divisional branching of the bronchial tree. It starts with, basically, the trachea.

Right, and then it gets kind of divided into the primary bronchioles, followed by secondary bronchioles, and then if there are multiple branchings at the end, it can be called tertiary bronchioles. This eventually further gets like a sub-branch which is called bronchioles and the tiniest of these air sac cells which are called alveolar sacs or alveoli cells. So, this is generally the branching network of the lung, starting from where the air can actually be consumed or inhaled, and after that, it is slowly distributed, and eventually, gas exchange happens, including oxygen and carbon dioxide, between the alveolar sac and the blood, or vice versa, from the blood to the alveolar sac. It is also very important to know the positions of the rib cage and diaphragm during inhalation and exhalation. So, the diaphragm is basically a kind of muscular membrane that is present beneath our lungs.

So, what happens, as you also know, is that the rib cage is basically a kind of structural network that gives protection to all these organs in the thoracic cavity, where the lung is an important component. And as you know, this is like a structure made of bone. So, both the diaphragm and the rib cage move in a certain manner. In the case of inhalation, what happens is that the diaphragm contracts. So, the diaphragm, once it contracts because we inhale a lot of air and oxygen, beneath which is the membrane that is the diaphragm, basically contracts.

And when it contracts, the rib cage basically expands, and it tries to kind of create more space for the inhalation process. Conversely, in the case of exhalation, what happens is that the diaphragm relaxes, and during exhalation, the rib cage basically contracts. So, it is essentially an opposite phenomenon. So, in case of inhalation, the diaphragm is contracted, while the rib cage is expanded to create more space for the intake of air. Conversely, in the case of exhalation, the diaphragm is relaxed and the ribcage is contracted.

Then we also have to discuss the role of surfactant in the lung. So, basically, surfactant can be dipalmitoylphosphatidylcholine. This can actually be secreted from epithelial type 2 cells. And this type of surfactant, which is kind of like a bilayer, like a lipid and protein bilayer, such as SP-A and SP-D, basically reduces the surface tension of the alveolar sac in the alveolar cells. Because without surfactant, you can see that there is a strong interaction between the liquid and the gas, or air, which can cause a strong attractive force, and thus, during the process of inhalation and respiration, there is a high risk that the alveolar sac may collapse.

But because we have the surfactant, it basically creates a bilayer membrane on top of the liquid, in between the liquid and gas, reducing the attractive forces between them. That means the reduction of the surface tension can be achieved. And as the surface tension is reduced, there is a lesser risk that this alveolar sac will collapse. So, in this way, different surfactants, especially dipalmitoylphosphatidylcholine, which is similar to SP-A to D, can help reduce surface tension, maintain the structural integrity of the alveolar sac or the alveolar cell, and assist in the proper respiration process. Then we will see different types of cells that are present in the lung.

For example, the most important cells that are present in the lung are the lung epithelial cells. These are basically a primarily specialized type of cell line, the airway and the alveoli of the lungs, which have a crucial role in protecting the respiratory system and also coordinating the immune response. These epithelial cells, which are present in the lung, also act as a barrier against inhaled particles and different types of pathogens, and they help in maintaining fluid balance, surfactant production, and tissue repair. So, this is one of the primary cells, as you can see. Then these cells have different kinds of categories of cells.

So, you can see ciliated cells, club cells, goblet cells, basal cells, and then type 1 and type 2 cells. So, let us see one by one the ciliated cells; you can see that they have a lot of these projections, hair-like projections. These cell lines are like the cell lines in the airways and possess hair-like projections called cilia, which, as you know, beat rhythmically to move mucus and different debris from the throat, clearing the airways. So, this hair-like projection basically moves dynamically, and using this rhythmic function, the cells can clear mucus and other debris from the air trackway. So, it basically keeps the clean path for inhalation and respiration processes.

Then you can see another type of specialized cell that is like goblet cells. They basically function in the secretion of mucus. And as you know, mucus coats the airway lining, eventually trapping any type of inhaled debris or pathogen. In this way, it does not allow pathogens or debris to go deep inside our alveoli to damage them. Next is the basal cell, and these are a specialized type of lung stem cell that can differentiate at any time into various other categories of cells whenever needed.

Then you can see that there are these AT-I and AT-II type cells, which are like alveolar type 1 cells and alveolar type 2 cells. So, alveolar type 1 cells are highly specialized for gas exchange. This makes alveolar type 1 cells one of the most important types of cells. They are essential for the exchange of oxygen and carbon dioxide during inhalation and respiration. The alveolar type 2 cells, on the other hand, secrete surfactant.

So, we already told what the role of surfactant is. The surfactant basically reduces the surface tension between the liquid and gas during the inhalation or exhalation process, and that way it maintains the integrity of the alveolar sac. So, the proper continuous respiration process happens. So, these AT2 type cells, or alveolar type 2 cells, only secrete surfactant, and in this way, they help maintain proper gas exchange and prevent the collapse of these alveoli. As you see, this is just a basic image of a healthy lung cell.

So, on the left side you have a healthy lung cell and on the right side you have an injured lung cell. So, there are different types of cells we already discussed; for example, the alveoli type 1 cell, type 2 cell, endothelial cells, and there are also different types of immune cells. So, in cases of healthy cells, you can see that there are proper pathways that are also filled with surfactant, and not too much recruitment of these types of immune cells is present. So, all types of immune cells in the case of healthy cells will have a relatively low number. But if there is a lung injury, it can be due to a chronic pulmonary disorder, it can be due to smoke, debris, or it can be due to any pathogen or bacteria.

You can then slowly see different types of immune cells that were highly recruited during the lung injury. So, you can see that AT-2 cells are becoming active, and the lung is also filled with edema fluid. So, different types of immune cells will get recruited near the injured lung, and they may also create fluid accumulation inside the lung. These immune cells will try to clear all those toxins or pathogens out of the lung. But there might be tissue damage, and you could say that tissue damage might occur due to toxins or pathogens.

So, this is just a clear kind of representation, and you will also see that there is probably a case where the amount of surfactant is decreasing inside the cells due to an inflammatory reaction. So, what are the different roles of long epithelial cells? Basically, they act as a barrier, preventing various harmful substances from entering the tissue. It also creates an immune response, right? So, basically, these lung epithelial cells express pattern recognition receptors, or PRRs, that can detect pathogens and initiate an immune response. These long epithelial cells also maintain fluid balance, and they have a very crucial role in different repair and regeneration processes. So, as you see in general, if we discuss the different functions of the lung, the primary function of the lung is gas exchange.

For example, during inhalation, it consumes oxygen, and during exhalation, it removes carbon dioxide from the body. Apart from that, in addition to the primary respiration process, the lungs also play a crucial role in maintaining the pH. It also has a role in the metabolism of different hormone drugs. It also has a crucial role in blood pressure regulation, then, of course, like surfactant production, and it also acts as a blood reservoir. So, let us see one by one in terms of pH regulation, as you know, whenever the lungs take in the carbon dioxide that is produced in different components of the body after cellular respiration or the metabolic process.

This carbon dioxide can actually get mixed in the blood, and as you know, when carbon dioxide mixes with water, it can form carbonic acid or bicarbonate. So, this type of molecule, carbonic acid, can actually create acidity in the blood; it can increase the acidity or influence the pH of the blood. So, in this way, the lungs can maintain and change the pH depending on the exhalation and inhalation steps. Apart from that, it also has important hormone and drug metabolism activity. For example, the lung has different enzymes involved in the cytochrome P450 system that can also metabolize different types of substances.

For example, hormone inactivation can happen where the lung can metabolize or inactivate circulating hormones, helping to regulate their levels in the body. It can also help in terms of drug metabolism, leading to either their inactivation or conversion into a different form. Then, as you know, the lung has a very important and crucial role in controlling blood pressure; it basically produces angiotensin-converting enzyme, which is the ACE enzyme, and this eventually converts angiotensin 1 to angiotensin 2. As we know, when angiotensin 2 is eventually formed, this hormone can constrict blood vessels. So, angiotensin 2 can vasoconstrict the blood vessels.

If it causes vasoconstriction, you can easily tell that the blood pressure will increase. Therefore, blood pressure will increase and blood flow will decrease. So, in this way, the lung, by secreting the ACE enzyme, influences blood pressure maintenance. Lungs can also act as a blood reservoir because they are part of pulmonary circulation and have a lot of high vascular networks. So, inside the lung, if the amount of vasculature that is present, it can take up to about 10 percent of the total blood volume in the body.

So, in this way, the lung can also store blood inside it using the vascular network close to it. So, let us think about it: how many lobes does the left lung have? Can you tell me which side of the body has a smaller lung and why? What is the function of the pleura, and can you also tell me what the term is for the space between the two lungs? So, let us think about this question. If you have any further questions, you can drop us your question by email; also, you can discuss your question during the live sessions. Thank you for attending another class of human physiology.

We will meet with you very soon in another class. Thank you.