Human Physiology
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Lecture – 40
Respiration - Part 4

Why is the deoxygenated blood is not as red? Or when we draw a diagram why do we give a blue color? Just blue, but there is scientific basis for that. So what is the basis? Carbaminohemoglobin has a distinctive blue color. Hello what I was talking about? Hemoglobin, it has been in the tissues, it has picked up carbon dioxide and what color it has gained now? Blue color. Therefore, contribute to the dark blue color that may contribute to the dark red color of the deoxygenated venous blood. That blue color that that whatever is the color of the venous blood that blue is tinge there is because it is the carbaminohemoglobin.

Now follow the story. We are still talking about carbon dioxide being transported by the blood. Now some of the facts - take the blood 100 ml which is been fully oxygenated at the level of lungs and returning to the heart. So far and that blood will enter into the what left auricle go to the left ventricle and then it will be pumped on the aorta. Let us say we let us collect let us presume that we are collecting the blood from aorta.

How much of blood have we collected? 100 ml and I will try to find out how much of carbon dioxide is there in that and I find that it is about 48 ml. All put together whatever it is it is how much is there? 48 ml. 48 ml are you ok so far? So that blood which is 100 same 100 ml how much of oxygen is present in that? 20 ml. How much is there right how much is there? 20 ml. That is what in terms of actual volume my 100 ml of that blood is going to contain 48 ml of what? 20 ml.

And what ml of oxygen? 20 ml. 20 ml ok. Now that blood goes into the tissue and Bohr effects etc whatever happens and then picks up the CO2. Now I am going to collect the blood from the venous system obviously it is going to have more carbon dioxide and that carbon dioxide I find is about 52 ml how much it is? So actually how much was added? 4 ml. 4 ml was added ok.

Now I will go I will take this blood with 52 volumes of CO2 back to the lungs and then I will get rid of carbon dioxide how much of carbon dioxide I am getting rid of? Again 4. Again 4 so it oscillates between 48 it does not go below 48 and does not go above 52. If you are healthy and if you are breathing normally and oxygen is abundantly available 48 – 52, 48 - 52 ok. Just as oxygen was 20 in the lungs 15 in the tissue, you are in that range

- of course there is some margin but you are in that range are you ok so far? Good. So where are we? We had oxygen dissociation curve, yes or no? So we are here we have a carbon dioxide dissociation curve, of course it is going to pick up carbon dioxide in the tissues and give it up in the lungs and we have seen how much 4 ml every time 4 ml per 100 ml of blood good good. Now let us talk purely in terms of partial pressure. Your oxygenated blood coming from the lungs - 100 ml contains how much of carbon dioxide - I told you just now 48 ml 48 ml in terms of partial pressure how much it is? 40.

40 how much very good how much it is? 40. So partial pressure of 40 means 48 ml of CO2 hello are you ok so far? We are all good so far. Then you take this blood to the tissues and when you go to the tissues you pick up carbon dioxide so you go - in terms of partial pressure you go from 40 to 45 but in terms of volume you go from 48 to 52 - not Greek and Latin very simple. I am talking the same thing in two different languages. In the language of partial pressure I am going from in the tissue I am going from 40 to 45 partial pressure in terms of actual volume I am going from where to where? 40 to 52. Now you would appreciate this. What does this indicate? On the x axis what do we have? 42 - 45. 42 - 45 just see there appreciate that 42 45 there.

Ok. And from there if you go to the x axis what do you get? 48 to 52. 48 to 52 what do you get you see from if I take these two points here on this line and this line and if I go here what do I get? Ok these are the two extremes in which the carbon dioxide is operating as we go from the arterial blood to the venous and back to that ok. Now life is more interesting than that. Just as we had Bohr effect where carbon dioxide was influencing the affinity of oxygen to hemoglobin - it was different in the lungs different in the tissues ok. Reverse is also true means what? Means what? Means that oxygen is influencing - you remember 23 percent of carbon dioxide is carried in the blood in the form of what? Carbaminohemoglobin. So the hemoglobin molecule as it goes which is sitting in the RBC and as it is going from the tissues ok, it has picked up carbon dioxide which is 23 percent of the total ok. And that 23 percent of that carbon dioxide molecule is combining with hemoglobin ok that itself is influencing the affinity of hemoglobin to oxygen in what direction I think I am absolutely sure you can guess the more the carbaminohemoglobin is formed as a result of carbon dioxide being picked up by the tissues - it reduces the affinity for oxygen. So you give more oxygen - one more amazing trick played by the hemoglobin molecule ok.

So the moment you become carbaminohemoglobin - you give more oxygen ok. And opposite will happen at the level of lungs ok - where the moment carbaminohemoglobin gives away carbon dioxide which was bound to hemoglobin ok its affinity for oxygen will go up. This is called as Haldane effect. What is it called as? Say that again Haldane effect. This is called as what? Haldane effect. Haldane effect ok. So now let us see -

this is actually the interesting case. To understand this figure I will try to explain to you. Let us just consider this very simple - the blood is coming from the lungs and going to the tissues good - partial pressure of carbon dioxide is 40 mmHg ok.

So partial pressure is 40 mmHg and how much of how much is the carbon dioxide 48 ml we have done that ok alright. Now the blood has gone to the tissues - in the tissues it has picked up carbon dioxide ok. The partial pressure of carbon dioxide in the blood has gone from 40 to 45 ok. Now when that is happening when the carbon dioxide has gone from 40 to 45 the blood has lost oxygen hello where? in the tissues the blood has what? It has lost oxygen ok. As a result of that the hemoglobin molecule has more affinity so it can combine with more carbon dioxide. Because it combines, the curve shifts in such a way that the curve shifts in such a way that when you are talking about the partial pressure of oxygen is 40 mmHg that is in the tissues you have the curve here where now you can carry 52 ml of oxygen. If that were not to happen now to appreciate the point - if that were not to happen and if this were the only curve then this will go from here to here - and here to here means 100 ml of blood can carry o from 48 to 50 which means increase in 2 increase. In that 2 ml - but because oxygen has gone away hemoglobin can combine more readily with carbon dioxide therefore, the same hemoglobin now can carry 4 ml of carbon dioxide - exactly opposite of Bohr effect and physiologists tell us that in practice Haldane effect is even more useful than the Bohr effect. It is more profound. So, please remember. Please try to. Now I am going to tell you a who is he - read for me John Scott Haldane he came up with of course, that is him.

Now, another trivia about Haldane. He had a son - the son's name was John Burden Sanderson Haldane - fellow of royal society. Now, why am I talking about his son? Very much so - in 1956 or so he had some - this is not science - this is trivia in science which makes science more interesting. In 1956 he had a problem with British government - who the son and he said goodbye I do not like you and then what did you do he came to India where did you go? Bhubaneshwar. He worked in Bhubaneshwar and there he died so his grave is in Bhubaneshwar. So, Haldane is Indians take that name Haldane with a lot of fondness because he took Indian citizenship - who not the not the dad what is his complicated - John whatever it is and he was and he look at his I want you - the British Indian scientist - can you read there? What about him? Known for his work in the study of physiology, genetics, evolutionary biology and mathematics he made innovative contributions in the field of statistics and biostudies. He was the son of. So, this is just an interesting side story I thought we should share and particularly known about Haldane because this name will come very often in several studies. Now, we are - hemoglobinic molecule is still not done with the tricks. Still more tricks - amazing is a molecule - never ceases to amaze. Beautiful molecule in the RBC. There is yet another very small compound called as 2, 3-diphosphoglycerate. Pease pronounce it for me once abbreviated as what? 2, 3-DPG. It is a very small molecule. Now, we are looking at this is a cartoon this is a cartoon of hemoglobin molecule and I am sure you can appreciate the 4 subunits are there each subunit is bound to an oxygen and more or less author tells us that this is somehow the orientation in which the 4 units are associated with one another.

Now, you take a look at this molecule - this is obviously, all 4 oxygen can you appreciate here O 2 O 2 O 2 O 2. It is a saturated molecule and obviously. This is in the lungs and this goes into the tissues and once it starts going into the tissues it loses 1 or 2 molecules of oxygen then second and third is gone, but fourth is not gone yet. It will go. As a result of giving away of the oxygen there is a some change in the dimension of 1 unit with reference to another unit. And then in the gap between the 2 subunits there is a little more gap and in that gap - fits the molecule. What is that molecule 2, 3-DPG. Whereas 2, 3-DPG has no affinity for the fully oxygenated molecule it has a great affinity for the molecule which is partly deoxygenated and once it sits in that - can you see that the 2, 3-DPG is sitting there in the second one - when it sits that last oxygen - which was sitting there is readily given away. So, this is yet another trick how the cell ensures that when you are in the tissue you want to make sure that you give as much as oxygen as possible and for that it has this molecule. So, this molecule - 2, 3-DPG is abundantly present in the RBC. Yes. It has been found that when you do exercise, it goes up. Look at the beauty of physiology because when you are doing exercise - obviously your requirement for oxygen has gone up and your physiological response is by generating more DGP so that you can give away the oxygen molecule. So this is the structure of DPG please. DPG is coming from where blood? It is in the blood. It is in the RBC. DPG is abundantly present of course, it has to interact with hemoglobin now it has to interact with hemoglobin it has to be in the RBC. It is in the RBC have no doubt.

But when you are doing the exercise the DPG level is increasing. So DPG is coming from the blood, or which one? 2, 3-DPG. 2, 3-DPG - we do not really know. We do not really know. That is a very good question. Where is it coming from because RBC of course cannot synthesize new DPG - we do not know maybe there is some literature. I have to read. What is your question say frame your question again. I will read let us see where is it coming from we try to find out. Now this DPG has a very interesting role we are looking at a pregnant mother and in her uterus you can see the fetus there. Are you ok? There and you can see that the placenta is there and why placenta is important because the baby is now of course, the baby does not have its own lungs so it is dependent on oxygen - so baby is actually dependent on the lungs of the mother. So, the mother gets the oxygen in the blood and then oxygen goes to the through the blood it goes to the placenta - in the placenta - the gaseous exchange will happen supposing both the fetus and the hemoglobin of the fetus and hemoglobin of the mother - they are not same. So, depending on the partial pressure of course, it will go it will go, but again the beauty of hemoglobin and I will explain it to you how it works.

4 subunits 2 alpha 2 beta are you ok 2 alpha 2 beta. When the baby is developing in the uterus of the mother there are different forms - there are different forms of hemoglobin. And are they just as in the adults? What we have 2 alpha hemoglobin molecule 2 alpha 2 beta are you with me. 4 are you ok so far? The baby will have will have 2 alpha. So, this is the point of birth. So, from here to here the baby is developing in uterus of the mother. Here the baby is born and this is beyond that right from the very as the blood is being synthesized you have alpha alpha alpha alpha. So, you collect the blood from the baby right from the beginning. You will have hemoglobin as 4 units 2 units are alpha done, but other 2 units are not beta - the other 2 units are maybe what is this I do not know what is this - zeta and then what is this – epsilon - whatever and delta and gamma. So, so these 2 versions come very early and go, but, I will draw your attention to the beta unit is low at the time of the birth only so much of beta is there.

So, if you take the if you take the blood of fetus you will find that in early stages it contains mainly the of course, the 2 units are alpha and 2 units are what? Are you getting it? It is not the same it is not the same it is not the same. It is only after the birth or so much after the birth of the 20 weeks that you have the adult composition of 2 alpha units and 2 beta units. So, mainly what is the message here - the blood of the fetus is made up of 4 subunits out of which 2 are alpha and 2 are gamma what are they 2 are alpha and 2 are gamma. Now, 2 interesting things happen. Whereas, the mother has more DPG a pregnant mother has more DPG which means what? Which means she will give away the oxygen more readily ok - on one hand on the other hand the fetus will have alpha and gamma. And alpha and gamma combination has almost no affinity for DPG which means it has more affinity for oxygen. Are you with me? What will the DPG do - give away oxygen. So, if you have no DPG what do you do - you bind more oxygen. Are you with me? Yes or no. Look at yet another trick of the hemoglobin molecule. So, the fetus by having in its blood hemoglobin that is made up of 2 alpha units and 2 gamma units it has DPG, but DPG cannot combine which means it has more affinity for oxygen which means the mother in her body has an additional part - which we know is a fetus. Which has far more affinity for oxygen - the oxygen will directly go before it goes anywhere else from the blood of the mother into the blood of the fetus. Appreciate the point ok.

Why the nature has come up with this amazing idea that in the fetus do not give 2 alpha 2 beta but have 2 alpha 2 gamma ok which has less affinity - it does not combine with DPG. More affinity it can draw more oxygen, but eventually after the birth the baby will lose the gamma unit and the baby will have a combination of 2 alpha and 2 beta. Here we have the green one is our classical here this is our classical 2 alpha hemoglobin with 2 alpha 2 beta units and the rest of the story is same - but as a result of the this, adult hemoglobin is HBF - F stands for fetus or fetal ok. As a result of that can you clearly see this partial pressure - at this partial pressure whereas, it can have so much of saturation at the same partial pressure this has so much saturation. Means it can combine far more oxygen - means affinity that is shown by the hemoglobin of the fetus is far more than that of the affinity of the mother. So, the mother mother's blood will take oxygen at the level of the lungs. It will go everywhere as it goes into the placenta on the other side of the placenta there is baby's blood that baby's blood has hemoglobin alpha alpha gamma - it has far more affinity. So, the baby will ensure that it will keep on drawing more oxygen which is required for its own development ok.

Alright we will stop now there are some videos I have given at the end please do go to the end of this talk. Thank you.