

# Hypoxia

## Introduction

Cellular Injury specifically Hypoxia. Hypoxia is Decrease of Oxygen. Hypoxia is one of the causes that lead to tissue injury. Injury mean a lesion or damage but not death. The injury affect the function leading to abnormal function.

## Etiology of Hypoxia

Cellular Injury has many causes. One of them is **Hypoxia**. Hypoxia is **Low Oxygen Delivery to the Tissues**. Oxygen is very important in the mitochondria in the Electron Transport Chain (ETC). Electron Transport Chain (ETC) produce ATP and the ATP produce Energy. The Energy is very important to the Cell. Uses of ATP are multiple like Pump and Channels that pump Na and K. So, when the Electron Transport Chain (ETC) stop and ATP decrease, the sodium can't enter the cells and potassium can't exit. therefore affecting the cell ability. The Hypoxia by definition is oxygen not reaching the cells. There are other causes for Cellular Injury like Inflammation (bacteria, virus, fungal, or chemicals), Trauma, or genetics (problem in the cell enzymes), etc. In this lecture, we will focus on Hypoxia, as it is a very important cause. Inflammation as a cause of Cellular Injury or even necrosis.

Causes of Hypoxia. Causes of why the oxygen doesn't reach the cells. The first and second causes are very important.

### **Ischemic (Stagnant): circulatory**

Let's assume this is an artery, and we have 4 cells, then we have a vein to return the blood. We have a thrombus clot in the artery (Atherosclerosis) blocking part of the artery leading to Decrease Arterial Perfusion to the cells. Atherosclerosis causing and mechanism of formation are explained in details in cardiology section. In some veins, there can be clots.

Example in Hepatic Vein Thrombosis in Budd-Chiari Syndrome. That would lead to Decrease Vein Drainage and congestion in the cells due to accumulation of the blood in them.

The problem can be in the source (the heart) like in Heart Failure. In Heart Failure, the heart doesn't pump enough blood. Or in case of shock, shock means severe decrease in blood pressure caused by Heart Failure, Bleeding (losing a large amount of blood). It is not a psychological Shock like if you took an exam that you had studied for very good, and you had a bad grade.

All these causes means Decrease in Blood Flow to the Organs.

### **Hypoxemic**

If there is no problem in both the arteries and veins. The cell still doesn't have enough Oxygen. The cell take the oxygen from the blood and the blood take the oxygen from the lung. The air enter the lung to the alveoli and from the alveoli, the gas exchange between Capillaries and alveoli occurs then the oxygenated blood circulate to the tissues. The oxygen first has to enter the alveoli, that process is called Ventilation. Then the oxygen has to cross to the capillaries and that process is called Diffusion. After the oxygen cross it need to be carried on hemoglobin in the blood, so blood flow is needed and that mean Arterial Perfusion need to be normal. For the oxygen to enter the bloody to reach the tissues successfully, there're 3 processes that need to happen properly Ventilation, Diffusion, and Lung Perfusion. Any defect in these processes the oxygen won't be able to reach the tissues.

Hypoxemic means the Oxygen present in the blood is Little unlike in Ischemic (Stagnant) case, where the oxygen was present in the blood but can't reach tissues due to obstruction. The oxygen level in the blood is measured by Oxygen pressure  $PaO_2 < 60$  mmHg. It should be 95-100. If it is  $< 60$  mmHg. The case is very bad. Oxygen is present in 2 forms: free and that is measured by  $PaO_2$  and normally it is around 100 mmHg and Bound to Hb and that is measured by Oximetry and it should be around 97%.

Oxygen didn't reach the alveoli and that is called Ventilation Defect. Ventilation Defect can happen in cases of Pulmonary Edema or Atelectasis. Oxygen can't cross to the capillaries and that is called Diffusion Defect. Diffusion Defect can happen if the membrane become thick like in cases of Fibrosis. Or the blood isn't reaching to the lungs, and that is called Perfusion Defect. Perfusion Defect can be due to a clot in the pulmonary artery called Pulmonary Embolism.

Other causes are like Hypoventilation. Hypoventilation : the patient isn't breathing properly. The muscle responsible for breathing is the diaphragm and it is supplied by the Phrenic Nerve. So, if the Phrenic Nerve is cut or inflamed, the patient won't be able to breath probably leading to Hypoventilation. The difference between Ventilation Defect and Hypoventilation: in Ventilation Defect, the defect is in the alveoli, while in Hypoventilation, the problem is entry of the air from the outside. In Hypoventilation, the alveoli is open but there is decrease in air entry. If a patient has a bacterial infection in the alveoli, that means there's Ventilation Defect as the air is entering the lung but not the alveoli. If a patient has a problem in the Phrenic Nerve, the air entry to the lung will be decrease caused by Hypoventilation. High Altitude: the atmospheric pressure decrease on heights like mountains so, the decrease in the atmospheric pressure affects your ability to breath air.

## Anemic

All is well from arteries, veins, ventilation, diffusion and perfusion but the blood doesn't have enough Hemoglobin. Decrease in RBCs: leads to decrease in Hb the oxygen carrier. CO Poisoning like Fire: in case of fire, the Carbon Monoxide form and normally Hb is bound to Oxygen but the minute Hb sees Co, he leaves the Oxygen and goes with the CO. Hemoglobin has high affinity for Carbon Monoxide more than for Oxygen. so, the cells don't get oxygen.

That can happen in case of fire, or bike fumes or other causes: the patient skin become Red. He has Cherry Red Appearance. It is treated by High Pressure Oxygen and monitor the patient's oxygen and vitals. Methemoglobinemia: the iron in the blood should be  $Fe^{++}$  but it is converted to  $Fe^{+++}$  and oxygen can only bind to  $Fe^{++}$ . so, the Hb loses its ability to carry oxygen. This is Methemoglobinemia and is caused by drugs like Sulfa, nitrate (sublingual nitroglycerin pills). To treat the patient give him Methylene Blue.

## Histological

Cyanide Poisoning: the oxygen reaches the cells but the cells can't use it to form ATP. That is because the cells are poisoned by Cyanide. The Cyanide poisons the cytochrome enzymes inside the cells. That also leads to Hypoxia



## Etiology of Hypoxia

### Important Notes:

#### Ischemic (Stagnant)

- o Decrease in Blood Flow to the Organs
- o Decrease Arterial Perfusion: Atherosclerosis
- o Decrease Vein Drainage: Budd-Chiari Syndrome
- o Shock: Heart Failure, Bleeding

#### Hypoxemic

- o  $\text{PaO}_2 < 60 \text{ mmHg}$
- o High Altitude
- o Hypoventilation: Phrenic Nerve defect
- o Diffusion Defect: Fibrosis
- o Ventilation Defect: Pulmonary Edema
- o Perfusion Defect : Pulmonary Embolism

#### Anemic

- o Decrease in RBCs
- o CO Poisoning like Fire: Cherry Red Appearance, High Pressure Oxygen
- o Methemoglobinemia: Sulfa, nitrate, ttt: Methylene Blue

#### Histological

- o Cyanide Poising