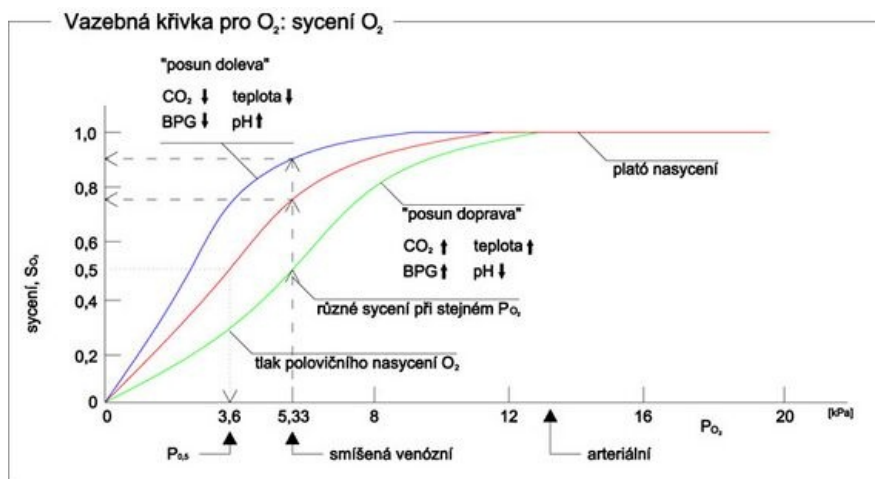


Transport of oxygen by blood

Oxygen, as a vitally important molecule, is transported by blood thanks to the blood pigment - hemoglobin. The binding of oxygen to hemoglobin has its own laws.

Oxygen bonding

Normally, **97% of the oxygen** in the blood flowing from the lungs to the peripheral tissues is **bound to hemoglobin (Hb)**. The remaining **3% are physically dissolved** in the plasma. The binding of oxygen to hemoglobin is, of course, reversible. If pO_2 is high, oxygen binds to hemoglobin (e.g. pulmonary capillaries), if pO_2 is low, oxygen leaves the bond with hemoglobin (e.g. tissue capillaries).



Physically dissolved oxygen occupies a volume of 3 ml in 1 liter of blood, then bound to hemoglobin around 197 ml. This is because 1 g of hemoglobin binds up to 1.34 ml of oxygen and the average concentration of hemoglobin in the blood is 150 g/l. In 5 l of blood, there is approximately 1 l of oxygen.

Physically dissolved oxygen occupies a volume of 3 ml in 1 liter of blood, bound to hemoglobin then around 197 ml. This is because 1 g of hemoglobin binds up to 1.34 ml of oxygen and the average concentration of hemoglobin in the blood is 150 g/l. There is therefore approximately 1 liter of oxygen in 5 liters of blood.

About **98% of the blood** that enters the left atrium passes through the pulmonary capillaries and is saturated with oxygen to **104 mmHg** (in our literature we often encounter a value of 100 mmHg). The remaining **2%** passes through the **bronchial circulation** (blood gets here from the aorta) and is not in contact with the pulmonary capillaries (so-called shunt flow). This blood has a **pO_2 value of 40 mmHg** - like normal systemic venous blood. These two components are mixed in the left atrium and thus the **resulting pO_2 in the left atrium is 95 mmHg**.

Blood leaving the lungs therefore has a pO_2 of 95 mmHg, which means that the **oxygen saturation is on average 97%** (see oxygen binding/dissociation curve). **Blood flowing out of peripheral tissues** has an average pO_2 of 40 mmHg, so its **saturation is 75%**.

Hemoglobin is saturated with oxygen according to the partial pressure of oxygen. This is shown by the saturation curve. It clearly has an ace shape, which proves that deoxyhemoglobin has a lower affinity for oxygen than oxyhemoglobin. With each oxygen molecule bound, hemoglobin's affinity for oxygen increases.^[1] At the same time, it points to the fact that even with a relatively high reduction in the partial pressure of oxygen in the blood, hemoglobin saturation does not significantly decrease

In blood that is 97% saturated, there is 19.4 ml of oxygen bound to hemoglobin per 100 ml of blood. After passing through the tissues, this value decreases to 14.4 ml O_2 (pO_2 40 mmHg, saturation 75%). It follows that normally **5 ml of O_2 is released from the blood into the tissues** for every 100 ml of blood (from 5 l of blood it is 250 ml of O_2).

Under normal circumstances, the interstitial fluid has a pO_2 of 40 mmHg (at this value, exactly 5 ml of O_2 from every 100 ml of blood passes into the interstitial fluid). During **vigorous exercise**, this value drops to 15 mmHg. This means that more oxygen is released from hemoglobin until only 4.4 ml of it remains bound to Hb in 100 ml of blood. Thus, **15 ml of O_2 reaches the tissue from every 100 ml of blood** ($= 19.4 - 4.4$). **The release of oxygen will thus increase threefold** (which, with an increase in cardiac activity - six to seven times - gives up to a twenty-fold increase in oxygen transport to the tissues).

Dissolved oxygen in blood with a pO_2 value of 95 mmHg is about 0.29 ml per 100 ml of blood. After passing through the tissues (40 mmHg), dissolved oxygen is 0.12 ml per 100 ml of blood. This means that only **0.17 ml of dissolved O_2** from every 100 ml of blood is released into the tissues (3% of the O_2 transported from the blood to the tissue - see above). During exercise, the proportion of that transport can drop to 1.5%. On the contrary, when inhaling oxygen with a high pO_2 , this proportion may increase and there may even be a risk of oxygen poisoning.

Factors affecting hemoglobin saturation

pH

- The lower the pH, the lower the affinity of hemoglobin to oxygen. Move right. (The so-called Bohr effect)

- The higher the pH, the higher the affinity of hemoglobin for oxygen. Move left.

pCO₂

- An increase in pCO₂ leads to a decrease in pH. This leads to a decrease in hemoglobin's affinity for oxygen. Move right.
- A decrease in pCO₂ leads to an increase in pH. This leads to an increase in the affinity of hemoglobin for oxygen. Move left.

Temperature

- The higher the temperature, the lower the affinity of hemoglobin for oxygen. Move right.
- The lower the temperature, the higher the affinity of hemoglobin for oxygen. Move left.

2,3-Bisphosphoglycerate

- The higher the concentration of 2,3-bisphosphoglycerate (BPG), the lower the affinity of hemoglobin for oxygen. Shift of the saturation curve to the right.
- The lower the concentration of 2,3-BPG, the higher the affinity of hemoglobin for oxygen. Shift of the saturation curve to the left.

2,3-BPG is important in adaptation to hypoxia - its concentration will increase.

How it is in the body

- Lungs = decrease in pCO₂ → higher pH → shift of the saturation curve to the left → oxygen binds to Hb
- Tissues = increase in pCO₂ → lower pH → shift of the saturation curve to the right → oxygen is released from Hb

Measurement

Hemoglobin oxygen saturation is measured by pulse oximetry . Saturation measurement is also part of the finger plethysmograph examination .

Links

Related articles

- Transport of CO₂ by blood
- Binding of oxygen to hemoglobin

Reference

1. TROJAN, Stanislav. *Medical physiology*. 4., reworked and edit edition. Grada Publishing, a.s, 2003. 772 pp. ISBN 80-247-0512-5.

References

- TROJAN, Stanislav. *Medical physiology*. 4., reworked and edited edition. Prague : Grada Publishing, a.s, 2003. 772 pp. ISBN 80-247-0512-5.
- GUYTON, Arthur C – HALL, John E. *Textbook of Medical Physiology*. 11. edition. Elsevier, 2006. 11; ISBN 978-0-7216-0240-0.