Binding of oxygen to hemoglobin

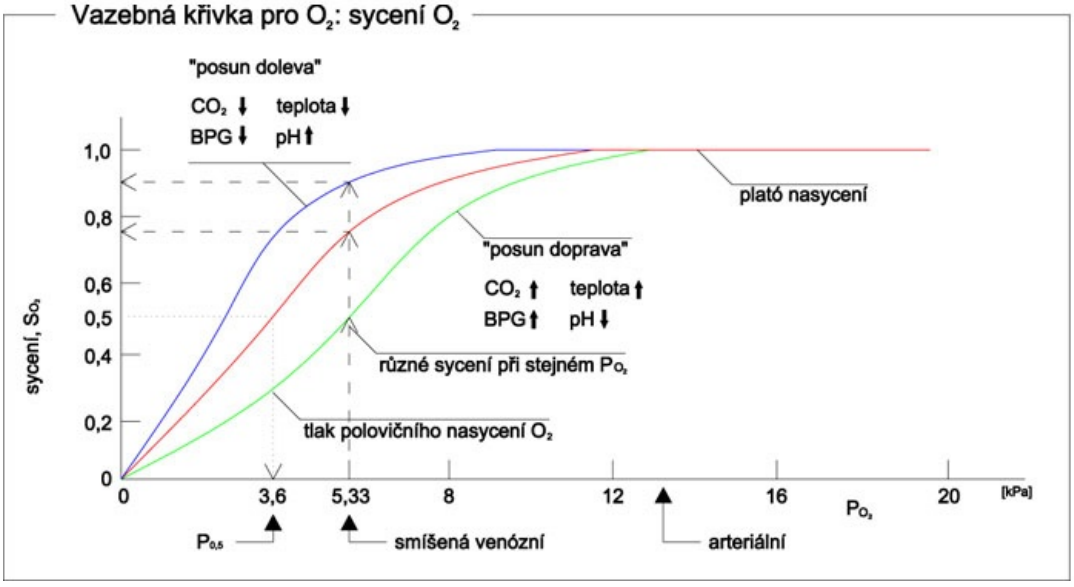
Oxygen is carried by blood 98.5% bound to hemoglobin (Hb). The remaining 2% are physically dissolved.

Transfer and Binding

One molecule of hemoglobin is able to bind **4 molecules of oxygen**, after binding we refer to it as oxyhemoglobin. Each of the 4 Fe^{2+} atoms is capable of reversibly binding 1 O_2 molecule. With this bond, iron remains divalent, so there is no oxidation, but **oxygenation**. Affinity for oxygen is influenced by the quaternary structure of hemoglobin. If the oxygen is not bound, it is deoxyhemoglobin, the globin units are tightly bound in a **tension configuration**. This reduces the affinity for oxygen. With oxyhemoglobin, a **relaxed configuration** is formed. After the binding of 1 molecule of O_2, the bonds with the globin units become looser and the affinity for oxygen increases.

Dissociation curve of hemoglobin for oxygen

The dissociation curve of oxyhemoglobin expresses the dependence of saturation and partial pressure of O_2 . The curve has a **sigmoidal shape**, which is caused by the transitions between the tensed and relaxed configurations of hemoglobin. Binding of the first O_2 molecule increases the affinity of the second heme to O_2 , binding to the second heme increases the affinity of the third, etc. We can distinguish the plateau region and the desaturation region. In the **plateau region**, hemoglobin oxygen saturation remains almost the same, despite changes in partial pressure. While in **the desaturation region** even a small change in partial pressure will cause a change in saturation. This will enable the necessary amount of oxygen to be released in tissues where the partial pressure of oxygen decreases. A shift of the curve to the right means a decrease in the affinity of Hb to O_2, a shift to the left has the opposite effect.



Factors influencing the binding of oxygen to hemoglobin

Effect of temperature

An **increase in temperature** shifts the dissociation curve of Hb for O_2 to the **right**, which means a decrease in affinity for O_2. Lowering the temperature has the opposite effect

Effect of pH

Oxygenated Hb (HbO_2) is a stronger acid than deoxygenated (Hb). **Decreasing** pH shifts the Hb dissociation curve for oxygen **to the right**. As the concentration of H^+ increases, hydrogen cations will bind to Hb, resulting in a decrease in affinity. CO_2 is also involved in pH changes. If excessive production of CO_2 occurs, it is immediately converted to bicarbonate anion and hydrogen cation. The resulting cations are thus involved in the drop in pH and the increase in desaturation of hemoglobin. The influence of carbon dioxide and pH on the affinity of hemoglobin for oxygen is referred to as the Bohr effect:

$$\mathbf{H_2O + CO_2 \rightleftharpoons H_2CO_3 \rightleftharpoons H_+ + HCO_3^-}$$

Effect of 2,3-diphosphoglycerate (2,3-DPG)

Red blood cells contain a large amount of 2,3-diphosphoglycerate, which is a product of glycolysis. It binds to the β chain of deoxyhemoglobin, stabilizes it and thus reduces the affinity for O_2.

Links

References

- KITTNAR, Otomar, et al. *Medical physiology.* 1. edition. Prague : Grada, 2011. ISBN 978-80-247-3068-4.
- GANONG, William F. *Review of Medical Physiology.* 20. edition. Prague : Galén, 2005. ISBN 978-80-247-3068-4.

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