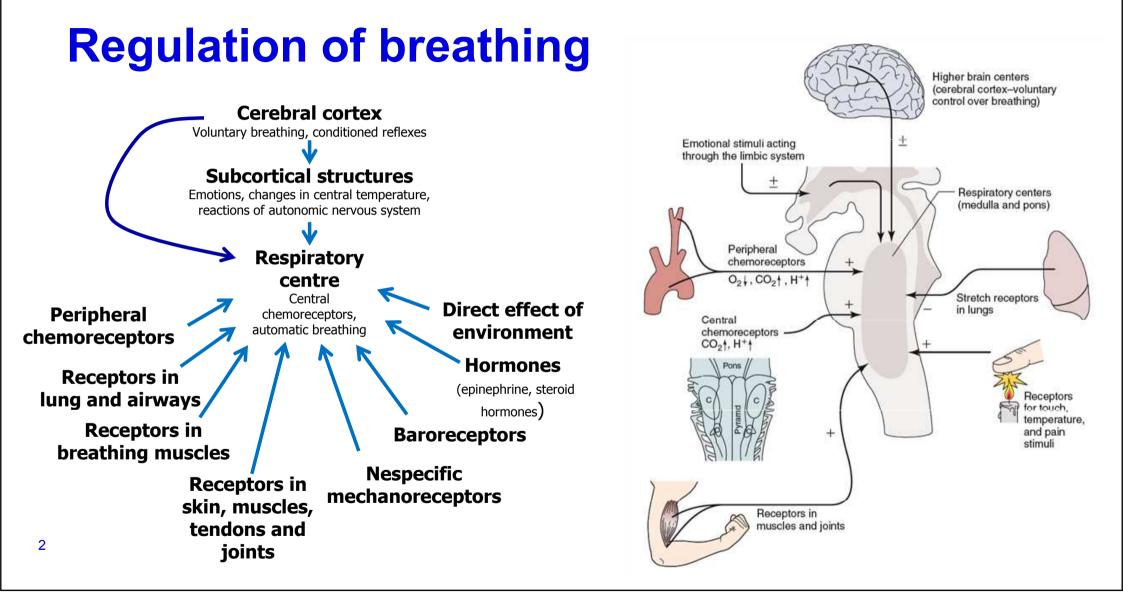
MUNI MED

Determination of the sensitivity of the respiratory center to hypercapnia

Physiology I – practice Autumn, weeks 7–9

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Breathing centres in the medulla

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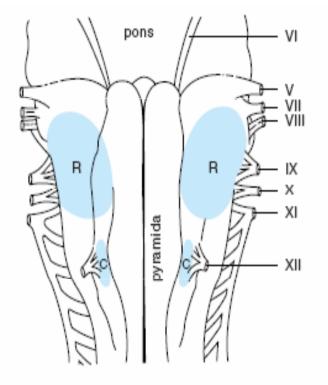
- Breathing is an automatic process that takes place unconsciously.
- Automaticity of breathing comes from regular (rhythmic) activity of groups of neurons anatomically localized in the medulla and its vicinity. They can be divided into three main groups:
 - Dorsal respiratory group only inspiratory neurons, their axons go to the motoneurons of the inspiratory muscles (diaphragm, external intercostal muscles; their activation = inspiration, during their relaxation = expiration), they participate in inspiration at rest and also during exercise
 - Ventral respiratory group located on the ventrolateral part of the medulla, the upper part: neurons whose axons activate the motoneurons of the primary and accessory inspiratory muscles; the lower part: expiratory neurons with innervation of expiratory muscles. Neurons of this group are active only during forced inhalation and exhalation
 - Pontine respiratory group (pneumotaxic centre) participates in the control of the frequency and depth of breathing; it affects the activity of respiratory neurons in the medulla

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Central chemoreceptors

- on the front side of the medulla
- CO₂ can cross the hematoencephalic barrier to the cerebrospinal and intercellular fluid
 CO₂ + H₂O → CHO₃⁻ + H⁺
- Higher H⁺ concentration of H⁺ in cerebrospinal fluid stimulates central chemoreceptors → increased ventilation
 - central chemoreceptor are stimulated also by other types of acidosis (lactate acidosis, ketoacidosis)
 - a sudden change of pCO₂ does not have an immediate effect, the changes in ventilation through central chemoreceptors occur after 20-30 s



Obr. 36-7. Rostrální (R) a kaudální (C) chemosenzitivní oblasti ventrálního povrchu prodloužené míchy

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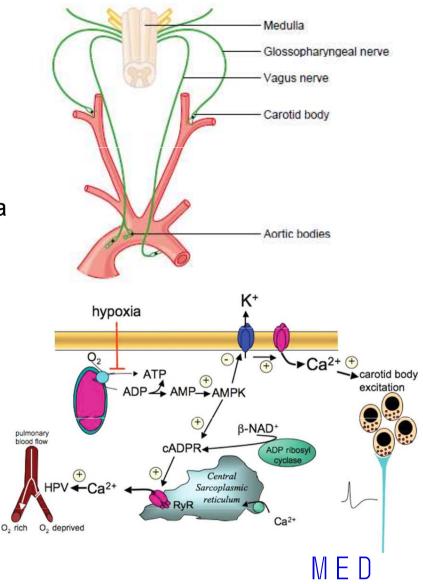
Peripheral chemoreceptors

- Located in the aortic and carotid bodies
 - glomus caroticum, glomus aorticum
 - They convey their sensory information to the medulla via the vagus nerve and glossopharyngeal nerve.
- Sensitive to a decrease in arterial pH and

 pO_2 and an increase in arterial pCO_2

- The most important reaction is to decrease in arterial pO₂, particularly to decrease of O₂ under 10-13 kPa in the arterial blood (caused mainly by a general decrease of pO₂ or impaired flow of the blood)
- Mechanism: decreased pO₂ leads to the decrease of ATP synthesis in mitochondria resulting in membrane depolarization





Hypoxia, hypoxemia (norm. 11-16 kPa)

- Hypoxia is a general name for a lack of oxygen in the body or certain tissues.
- Hypoxemia is a lack of oxygen in arterial blood.
- A complete lack of oxygen is known as anoxia.
- The most common types of hypoxia:
 - Hypoxic physiological: stay at higher altitudes, pathological: hypoventilation during lung or neuromuscular diseases, thorax injuries, opioid overdose, …
 - Transport (anemic) reduced transport capacity of blood for oxygen (anemia, blood loss, CO poisoning)
 - Ischemic (stagnation) restricted blood flow to tissues (heart failure, shock, obstruction of an artery)
 - Histotoxic cells are unable to utilize oxygen (cyanide poisoning disruption of the respiratory chain)
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Hypercapnia (norm. 5.3-6.65 kPa)

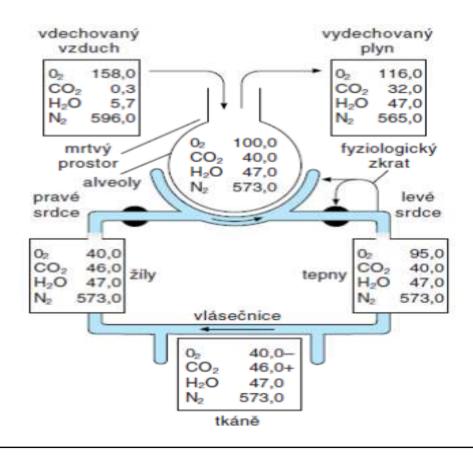
- An increase in the concentration of carbon dioxide in the blood or tissues caused by the retention of CO₂ in the body
 - Possible causes: total alveolar hypoventilation decreased respiration or extension of dead space
 - Mild hypercapnia (5-7 kPa) causes stimulation of the respiratory center (therapeutic use: pneumoxid = mixture of oxygen + 2-5% CO₂)
 - Hypercapnia around 10 kPa CO₂ narcosis respiratory depression (preceded by headache, confusion, disorientation, a feeling of breathlessness)
 - Hypercapnia over 12 kPa significant respiratory depression coma and death.

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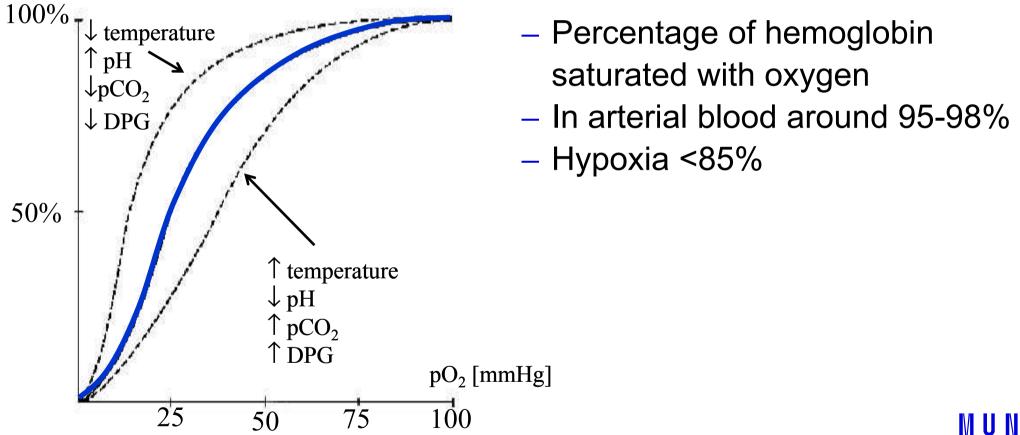
The partial pressure of gases (mmHg)

- In different parts of the respiratory and circulatory system



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Saturation of hemoglobin with oxygen



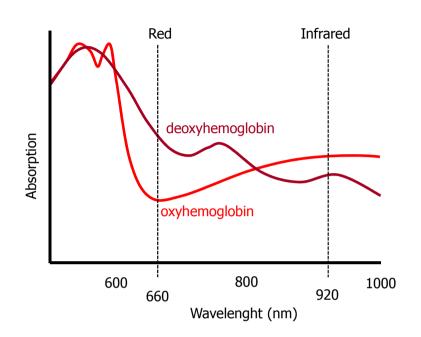
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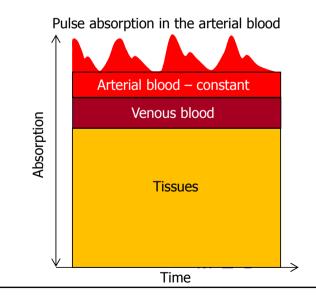
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Pulse oximetry



- Is a photometric method of non-invasive measurement of hemoglobin saturation with oxygen in the arterial blood.
- The method is based on the evaluation of the absorption of transmitted light of two different wavelengths after passing through tissues.
- How to get saturation only in the arterial blood: subtract the value between individual heartbeats from the value at the peak of the pulse wave. The component calculated in this way is then equal to the absorption of the variable component, which is the arterial blood (the representation of other tissue is stable).



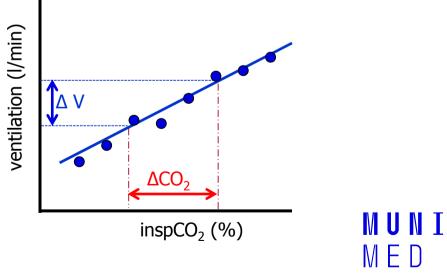


Sensitivity of the respiratory centre to hypercapnia

- Aim: to demonstrate the changes in ventilation during induced hypercapnia and to compare the sensitivity of the respiratory centre to hypercapnia in several subjects
- Method: Hypercapnia is induced by re-breathing of air expired into Krogh respirometer with a closed circuit (Krogh respirometer with oxygen, without the soda lime – the CO₂ concentration naturally increases)
- Interpretation: The slope of the curve shows the sensitivity of the respiratory centre to hypercapnia

$$\frac{\Delta V}{\Delta CO_2} \ [l/\min \cdot \%]$$

Clinical note: the sensitivity of the respiratory centre to change of partial pressure of CO_2 is reduced in patients with chronic end-stage lung disease, in patients with heart failure as well as in subjects training breath holding (e.g. divers without oxygen tanks)



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