SIM – PHYSIOLOGY E-BOOK

(SIM LAB GUIDE for 2nd YEAR MEDICAL STUDENTS)

B1

- Introduction to Simulation Medicine in Physiology Course
- Primary Investigation and Evaluation

B2

- Handover (SBAR)
- Circulation, Blood Pressure, Determinants of Blood Pressure

B3

- Respiration
- Relationship between Respiration and Circulation
- Oxygen Supply (DO2)
- Determinants of Oxygen Delivery (DO2)

B4

- CO2 elimination
- Capnometry
- etCO2 variables
- Monitoring of the Organism during General Anesthesia
- Reaction to a Change in Condition

B5

- Invasive Blood Pressure Measurement
- Determinants of Glomerular Filtration

B6

- Consciousness (determinants and evaluation)
- Intrinsic Environment

B3

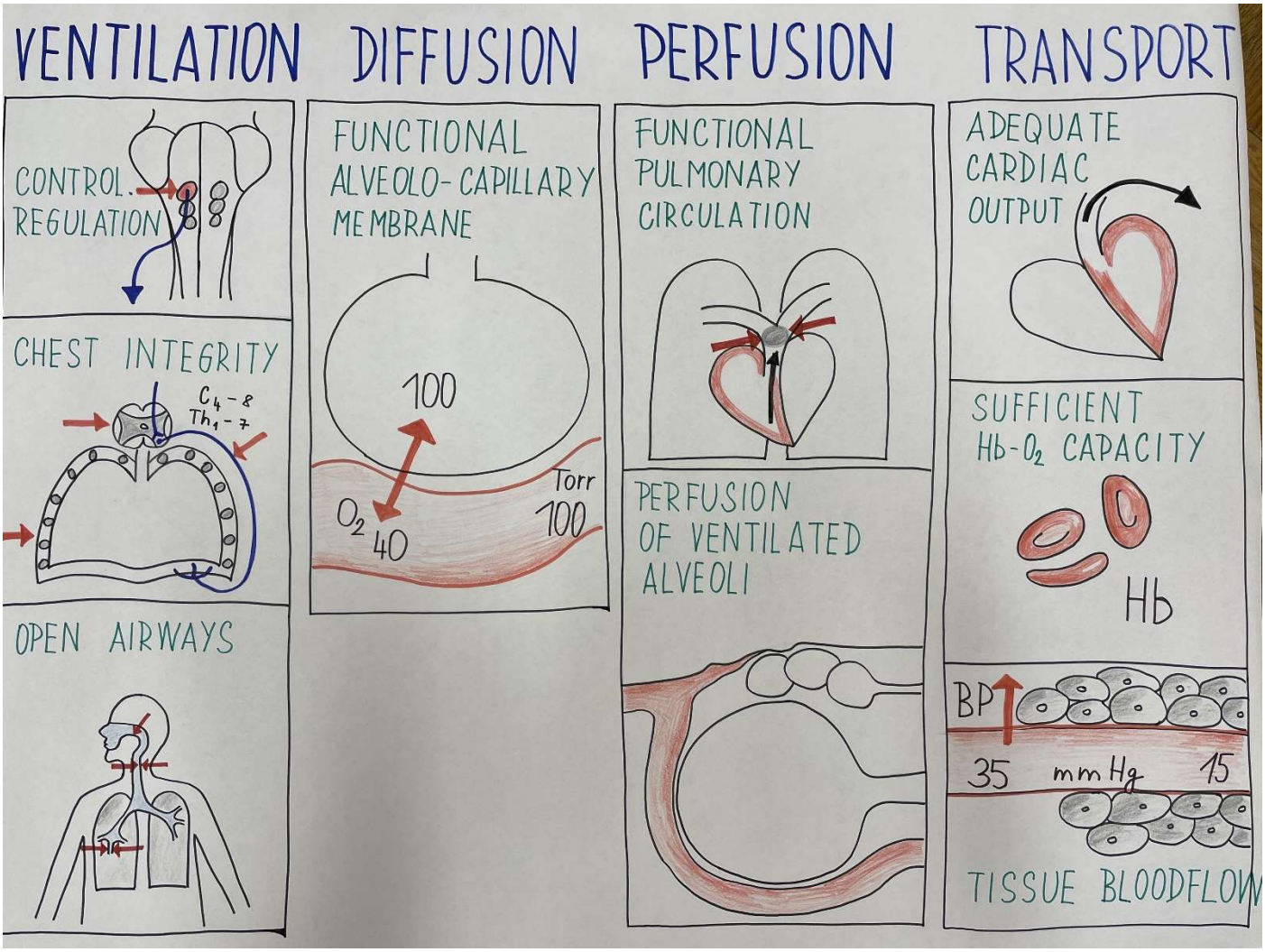
RESPIRATION AND THE RELATIONSHIP BETWEEN RESPIRATION AND CIRCULATION

- The main function of the respiratory system is the exchange of respiratory gases (O2 and CO2) between the organism and the environment.
- See also B4, capnometry.
- This is only possible in cooperation with the circulatory system and the transport systems of the blood (hemoglobin – the main transport mechanism for O2, bicarbonate – the main transport mechanism for CO2).

OXYGEN DELIVERY (DO2), DETERMINANTS OF DO2

The aim of the B3 program is to supplement the previous one (B1, B2) with the knowledge and skills necessary to assess the supply of O2 to tissues and **understand the mechanisms that limit it:**

DO2



EXAMINATION

Sight + Touch

- Presence/Absence of Breathing
- Symmetric/Asymmetric Chest Expansion
- Counting The Respiratory Rate
- Evaluating the Depth of Breath (Breath Volume) (with the palm placed on the chest)

Meaning: Assessment of Ventilation

Percussion: This assessment requires training and experience in assessing the sound created over different tissues (based on how airy/ dense the tissues are) or effusion in the pleural cavity, will be covered in more detail in internal propaedeutics. During the second year, it is good to master the technique of correct percussion, (instructions and practice to be provided in practical exercises in physiology.) The dummies do not allow the examination to be assessed by percussion.

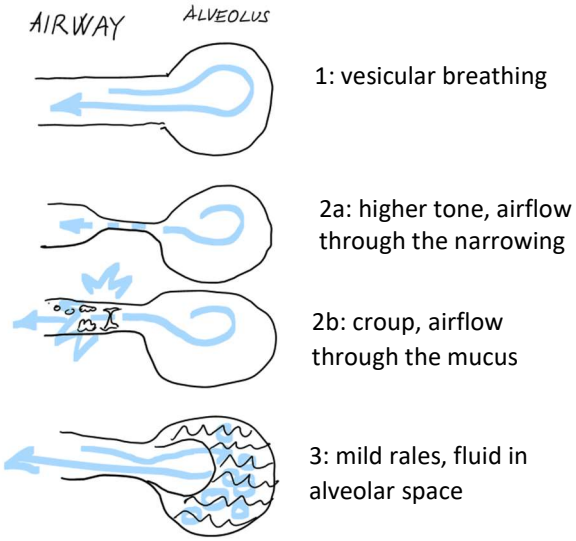
Meaning: Assessment of Ventilation and Distribution

Listening:

1. Physiological Condition: alveolar breathing

2. Respiratory Tract Disorders:
   2a : narrowing (swelling, spasm) – high tone
   2b : mucus - croup

3. the presence of fluid in the alveolar space (example: inflammation of the lung parenchyma or pathological infiltration of the alveolo-capillary membrane - if the blood pressure in the capillaries of the small circulation exceeds the value of the oncotic pressure in case of circulatory failure (see Starling's forces, pathophysiology in more detail) - small rales caused by the re-expansion of the moist alveoli during inspiration or by bubbling air through the fluid in the alveolar space during inspiration



Importance of listening: distinguishing between disorder:

- **Ventilation** (non-physiological finding in the airways)
- **Diffusion** (fluid in the alveolar space)

Note :
The given explanation is simplified for the understanding of the principle, for more details see pathophysiology, internal propaedeutics and internal.

Arterial blood saturation, SpO2

- SpO2 expresses the percentage of currently occupied hemoglobin binding sites for O2.

- Measurement method:
  1. non-invasively: pulse oximetry
  2. invasively: by analyzing a blood sample

- Pulse Oximetry:

  - Uses two main principles:

  1. Measurement of absorption spectra of oxyhemoglobin and deoxyhemoglobin
  2. Fluctuations in the volume of arterial blood in the tissue during the pulse wave cycle, in contrast to the volume of venous and capillary blood, which does not fluctuate or pulsate.

  - The pulse spectrophotometer registers the absorption spectrum of all blood contained in the measured tissue and selects only values corresponding to arterial blood (pulsating signal).
  - Normal value: 95-98 %, with age it can be even lower
  - Cyanosis is correlated with reduced arterial blood saturation, which is manifested by a bluish discoloration of the skin of the mucous membranes and nail beds. It is observed roughly when the content of reduced hemoglobin is >50 g/l of arterial blood.
  - Reduced saturation is often accompanied by shortness of breath (feeling of lack of air). This can be caused by irritation detected by the mechanoreceptors of the lungs during changes in the mechanical ventilation (greater work of breathing) or from the chemoreceptors which detect pCO2, pH (central in the brainstem), pO2 (peripheral in the carotid bodies).

ASSESMENT

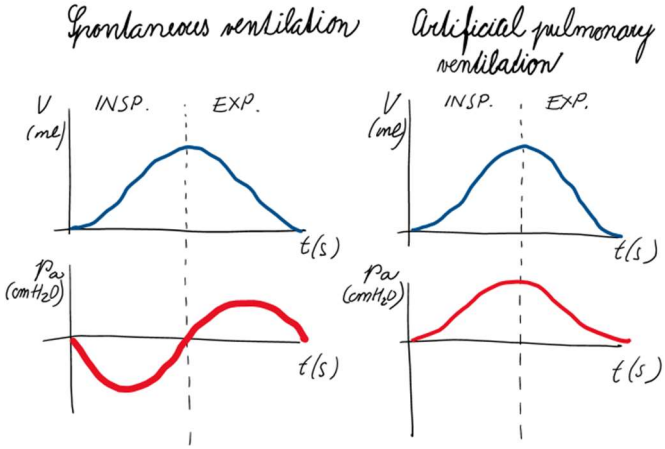
Critical condition requiring immediate intervention: absent respiratory activity or insufficient minute ventilation leading to decreased oxygen saturation.
If the patient complains of shortness of breath, it should not be assessed as satisfactory.

REACTION

It depends on the mechanism that limits O2 supply:

For example:

- If ventilation (breathing movement) is missing, it needs to be replaced - artificial ventilation (breathing with excess pressure)
- If the airways are narrowed by bronchospasm, administer bronchodilators
- If the diffusion membrane is thickened, increase the concentration gradient for oxygen.



Mechanical Ventilation

Synonym: Artificial Pulmonary Ventilation
Options: manual (with a bag) or instrument (with a machine)

Graph:
Tidal volume V (ml) and intra-alveolar pressure p_a (cm H_2O) during the respiratory cycle (inspiration , expiration)

Differences between:

- ***spontaneous ventilation*** ('negative pressure' breathing) and
- ***artificial pulmonary ventilation*** ('overpressure' breathing):

Insufficient SpO2 with adequately increased minute ventilation → oxygen therapy

Oxygen therapy: Enrichment of the Inhaled Mixture with Oxygen.

Helps according to the effectiveness of the achieved pO_2 in the inhaled mixture:

- Mask with reservoir > Mask without reservoir > Oxygen goggles.
  For others, see the appendix to the protocol.

RESOLUTION

The goal of this table is to determine the underlying cause which is currently limiting the supply of O2. For this, we will use the result of the examination and the reaction to the intervention (improvement/no improvement).

DO2	Cause of failure (some examples)	Symptom	Response
Ventilation	Inadequate respiratory activity	Lack of chest movements, Flow of exhaled air	Introduction of adequate ventilation, SpO2 normalizes
	Airway Obstruction	Lack of flow of exhaled air, Retraction of the jugular vein	After clearing the airways with adequate past ventilation, SpO2 normalizes
	Airway Narrowing	Auditory finding – wheezing in expiration	After pharmacological bronchodilation, SpO2 normalizes
Diffusion	Thickening of the diffusion membrane by the transfer of fluid into the interstitial space or even into the alveolar space	Ventilation effort is usually higher (higher frequency and depth of breath) By auscultation, we can detect alveolar breathing (fluid in the interstitial space), or we can hear crackles at the top of inspiration (fluid in the alveolar space).	The decreased SpO2 should improve in both cases after increasing the pO2 in the inspired mixture using an O2 mask. If it does not improve, it is either a very significant diffusion disorder or another disorder (e.g., perfusion).
Perfusion	Impaired pulmonary perfusion can be caused either by obstruction of the pulmonary artery by a thrombus (thromboembolic lung disease) or by impaired regulation of the ventilation- perfusion ratio. See textbook V/Q ratio and then pathophysiology.	The physical finding may closely resemble a diffusion disorder. By auscultation, we can detect alveolar breathing and crackles (also due to associated chronic diseases).	Decreased SpO2 does not improve significantly in perfusion disorder after administration of O2.

Transport	Decreased cardiac output (CO)	CO: To assess it directly, we need heart rate and stroke volume. Stroke volume can be determined most accurately by invasive measurement. This is reserved for critical conditions where a severe reduction in cardiac output is very likely. In the vast majority of cases, we can suffice with an indirect assessment of cardiac output based on: the presence of a combination of the following parameters: sinus rhythm, adequate heart rate, blood pressure and peripheral blood flow (CRT) values. Cardiac output can still be assessed indirectly on the basis of the sonographic image: the size and mobility of the heart chambers during the cycle.	Addressing the cause of reduced cardiac output
	Reduced blood transport capacity for O2:	Determination of hemoglobin concentration in blood.	Increasing the hemoglobin concentration by blood transfusion (if the hemoglobin concentration is acutely limiting) or by supporting erythropoiesis (if the condition is not critical, this is a better solution)