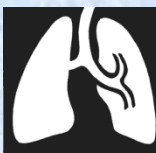


Respiratory insufficiency

Dif. dg. of dyspnea

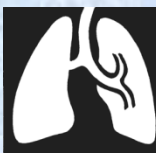
Oxygen therapy

Libor Fila



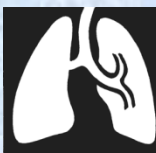
Respiratory insufficiency

- Condition with $p_aO_2 < 8.0$ kPa and/or $p_aCO_2 > 6.5$ kPa if FiO_2 is 0.21
- Acute, chronic and chronic with acute worsening
- Hypoxemic and hypercapnic
- Latent (during exercise) and manifest (at rest)
- Compensated and decompensated (with acidemia)
- Stable and unstable (encephalopathy, heart failure, variation of $p_aO_2 > 1.3$ kPa/2 months)



Tissue oxygenation

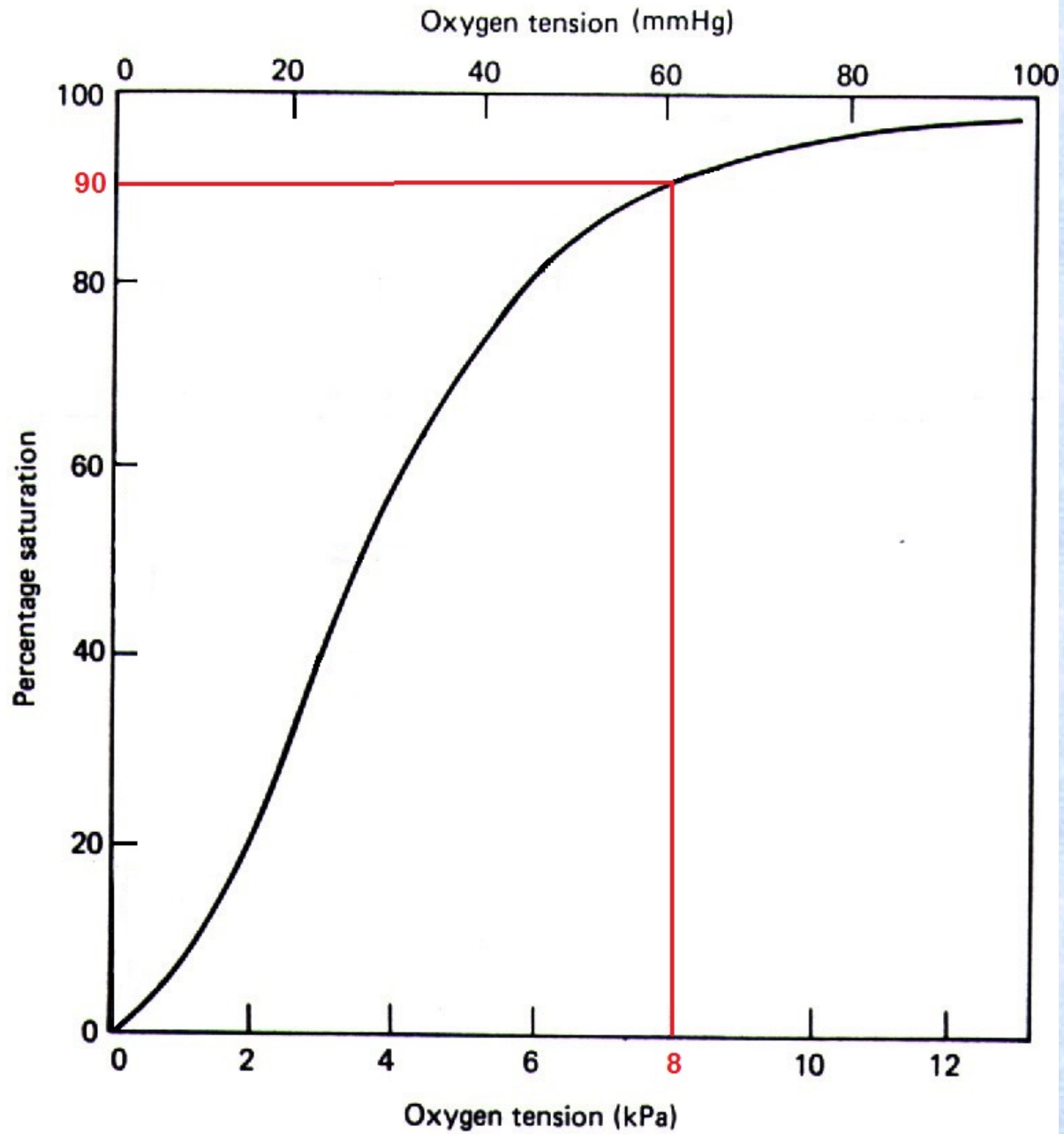
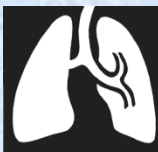
- Gradient of O_2 across the inner mitochondrial membrane
- Depends on:
 - Haemoglobin concentration
 - Oxygen saturation of haemoglobin
 - Cardiac output
 - Tissue distribution of perfusion

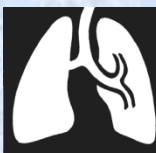


Severity of disorders

(normal p_aO_2 is 11.4-13.3 kPa in age 20 years)

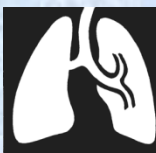
Disorder	Mild	Moderate	Severe
Hypoxemia (kPa)	8.00-LLN	6.50-7.99	<6.50
Desaturation	90-94%	85-89%	<85%
Hypercapnia (kPa)	6.01-6.50	6.51-8.00	>8.00
Acidemia (pH)	7.30-7.34	7.25-7.29	<7.25





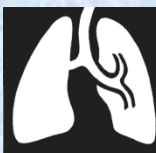
Blood gases & acid-base balance/1

- Arterial blood (a. radialis, a. brachialis, a femoralis)
- Arterialized blood (ear lobe, vasodilatation with Finalgon)
- Anaerobic sampling into heparinized capillary
- Immediate examination or in 20 minutes with storing on ice



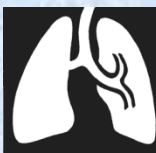
Blood gases & acid-base balance/2

- Measured values: p_aO_2 , p_aCO_2 , pH
- Calculated values:
 - HCO_3^- and BE (from p_aCO_2 and pH)
 - S_aO_2 (from p_aO_2 and pH)
 - $A-aD_{O_2}$ (from p_aO_2 and p_aCO_2)
- $A-aD_{O_2}$ differentiates „lung failure“ (respiration failure - higher) from „pump failure“ (ventilation failure - normal)



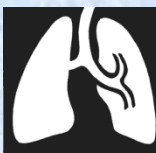
Acid-base balance disorders

- Acidemia (blood pH <7.35)
- Alkalemia (blood pH >7.45)
- Acidosis, alkalosis: disorders with tendency to change pH
- Metabolic alkalosis and acidosis (normal BE is between -2.5 and 2.5)
- Respiratory alkalosis ($p_a\text{CO}_2 < 4.5 \text{ kPa}$) and acidosis ($p_a\text{CO}_2 > 6.0 \text{ kPa}$)



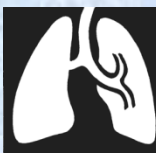
Metabolic disorders of ABB

Metabolic acidosis		Metabolic alkalosis	
Disorder	Parameter	Disorders	Parameter
Haemodilution	↓ Na ⁺	Haemoconcentration	↑ Na ⁺
Hyperchloremia	↑ Cl ⁻	Hypochloremia	↓ Cl ⁻
Hyperphosphatemia	↑ phosphates	Hypoalbuminemia	↓ albumin
Excess of UA ⁻	Lactic acid Ketones Sulphates Salicylates Methanol Ethylene glycol		



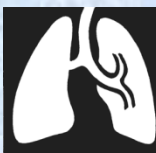
Hypo- a hypercapnia

- Normal $p_a\text{CO}_2$: 4.5-6.0 kPa
- Respiratory point of view: hypo- and hypercapnia
- Ventilatory point of view: alveolar hypo- and hyperventilation
- ABB point of view: respiratory alkalosis and acidosis



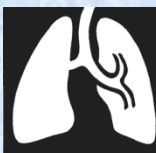
Origin of respiratory insufficiency

- Alveolar hypoventilation
- Ventilation/perfusion mismatch
- Right-to-left shunt
- Disorder of diffusion



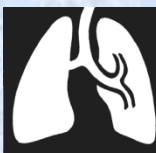
Respiratory centres & receptors

- Respiratory centers: in medulla oblongata, controls respiratory movements
- Central chemoreceptors: ventrolateral medullary surface, measures pH of cerebrospinal fluid
- Peripheral chemoreceptors: carotic bodies, measures p_aO_2



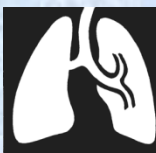
Causes of respiratory insufficiency

- Airway obstruction
- Pulmonary parenchymal disorders
- Cardiovascular disorders
- Pleural disorders
- Chest wall disorders (neuro- musculo- skeletal)
- Central nervous system disorders
- Environmental factors



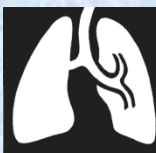
Dyspnea: definition

- Subjective feeling of shortness of breath or difficult breathing
- Emotional impact: threatening of life
- Healthy persons don't perceive increased respiratory effort (eg. heavy physical exertion) as negative



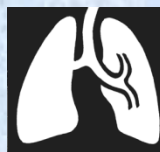
Dyspnea: perception

- Perception of dyspnea is individually different
- Possible effect of centrally depressant drugs
- Peripheral aspect: the work of respiratory muscles is not accompanied by adequate ventilation or the ratio between current and maximum minute ventilation is increased
- Central aspect: excessive stimulation of respiratory center (psychological and metabolic effects)



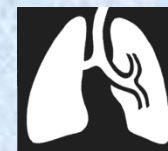
Dyspnea: causes

- Other causes beside RI:
 - Anemia
 - Metabolic acidosis
 - Deconditioning (low exercise tolerance)
 - Neuropsychic (eg. panic attack)



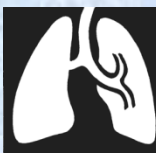
Grades of exertional dyspnea (WHO)

- Grade 0: No breathlessness
- Grade 1: Breathlessness when hurrying on the level or walking up a slight hill
- Grade 2: Walks slower than people of the same age on the level because of breathlessness or has to stop for breath when walking at own pace on level
- Grade 3: Stop for breath after walking about 100 meter or a few minutes on the level
- Grade 4: Too breathless to leave the house or breathless when dressing or undressing



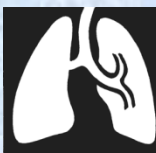
Dyspnea: history

- Rapidity of onset
- Duration
- Day time
- Character
- Provoking factors
- Relieving factors
- Accompanying symptoms
- Previous diseases



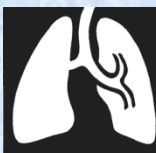
Accompanying symptoms

- Cough
- Expectoration
- Chest pain
- Palpitation
- Fever
- Sweating
- Weight loss
- Swelling



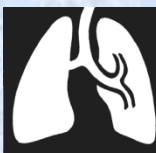
Dyspnea: physical examination

- State of consciousness, ability to communicate
- Cyanosis, paleness
- Respiratory and heart rate, blood pressure
- Neck: scars, goitre, jugular veins, swelling
- Lungs: percussion, auscultation
- Heart: auscultation, arrhythmias
- Limbs: edema, digital clubbing



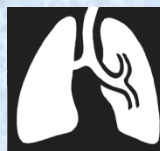
Dyspnea: complementary examination

- First line: Chest X-ray, ECG, pulse oximetry
- Blood count, D dimer, CRP, Tn I, BNP...
- Blood gases, ABB, lactic acid
- Chest US and CT, pulmonary CT angiography
- Laryngoscopy, bronchoscopy
- Specialist: cardiologist, pulmonologist, neurologist, psychiatrist, ENT...



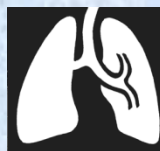
Emergencies

- Aspiration of foreign body, laryngeal edema
- Laryngospasm, bronchospasm
- Lung edema (left heart failure, ARDS)
- Pulmonary embolism
- Pneumothorax, hemothorax
- Serial rib fractures, lung contusion
- Myasthenic crisis, tetanus, botulism
- Drowning, inhalation injury



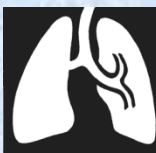
Illustrative case /1

- Man, 20 years old, tall and slim
- Rapid onset of breathlessness with stabbing chest pain
- Hyperresonant percusison and decreased breath sounds over left lung
- ???



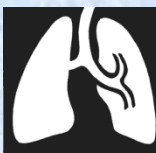
Illustrative case /2

- Woman, 30 years old, smoker with contraceptive pills
- Rapid onset of breathlessness with mild hemoptysis and stabbing chest pain
- Normal lung physical examination, left leg swelling
- ???



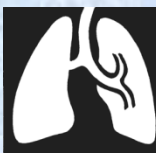
Illustrative case /3

- Man, 40 years old, got chilled during physical exercise
- Increasing dyspnea over 2 days with fever and purulent sputum
- Wet crackles in left axilla
- ???



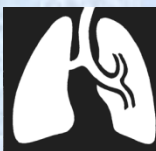
Illustrative case /4

- Woman, 50 years old
- Slowly increasing exertional dyspnea over 3 months
- Bibasilar lung crepitations, finger clubbing
- ???



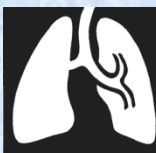
Illustrative case /5

- Man, 60 years old, smoker 80 pack-years
- Slowly increasing exertional dyspnea over 2 years
- Decreased breath sounds, rhonchi over both lungs
- ???



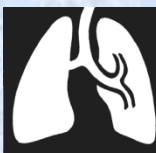
Illustrative case /6

- Woman, 80 years old
- Long-term exertional dyspnea, acute worsening with nocturnal dyspnea
- Bibasilar lung wet crackles, swelling of both ankles
- ???



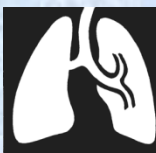
Treatment of respiratory insufficiency

- Treatment of underlying disease
- Oxygen
- Mechanical ventilation
- Surgical treatment
- Symptomatic treatment



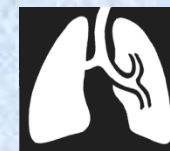
Oxygen therapy

- Oxygen sources in medicine
- Ways of oxygen administration, flow
- Temperature, humidification
- Oxygen toxicity



Oxygen flow

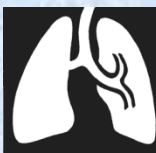
- Oxygen glasses: 0.5-4 L/min.; FiO_2 up to 0.35
(2 L/min. = FiO_2 0.28, 4 L/min. = FiO_2 0.35)
- Oxygen mask: 5-10 L/min.; FiO_2 up to 0,50
- Oxygen mask with reservoir: up to 20 L/min.;
 FiO_2 up to 1.0
- Venturi-mask: FiO_2 0.28-0.98
- Endotracheal cannula: FiO_2 0.21-1.0



Humidification and warming of oxygen, oxygen toxicity

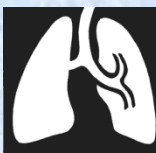
- Humidification and warming of oxygen is necessary in flow >4 L/min.
- Threat of oxygen toxicity exist in $FiO_2 >0.6$ continuing >48 hours (ALI/ARDS)





Mechanical ventilation

- Positive and negative pressure ventilation
- Invasive and noninvasive ventilation
- Regimens of mechanical ventilation
- Weaning from ventilator



Noninvasive ventilation

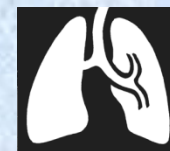


- Nose and face masks
- Full face shield
- Helmet ventilation
- Devices of CPAP or BiPAP style

Invasive ventilation

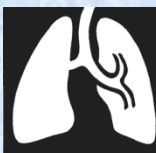
- Invasive approach into airways
- Orotracheal or tracheostomy cannula





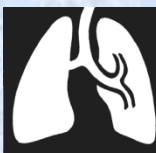
Long-term invasive ventilation





Ventilation regimens

- Full or part ventilatory support (replacement of work of breathing)
- Pressure or volume control of ventilation
- Synchronous (with inspiration) or asynchronous
- Alternative modes of ventilation: high-frequency jet and oscillatory ventilation



Surgical methods

- Upper airways surgery in sleep apnea syndrome (eg. uvulopalatopharyngoplasty)
- Tracheostomy (decreased dead space, easier airway clearance and connection with ventilator x loss of sense of smell, abdominal press and PEEP from glottis and lips)
- Bullectomy, lung volume reduction surgery (COPD)
- Lung transplantation (carefully selected patients)



Something to remember:

- Evaluate state of consciousness and ability to speech
- Low-flow oxygen therapy in COPD
- Dyspnea in anemia and metabolic acidosis
- Absence of breathlessness in CO poisoning