**LECTURE SYLLABUS**

**(General medicine, dental medicine)**

**Pathophysiology of respiration**

**Breathing (respiration)** = processes of respiratory gasses exchange between the environment and the organism

**External (pulmonary) respiration** = gas exchange between the environment and the lungs, between the lungs and the blood

**Internal (tissue) respiration** = gas exchange between the blood, interstitial fluid and the cells

Pathophysiology of breathing deals with:

* Lungs
* Airways
* Pleura and pleural cavity
* Chest wall
* Mediastinum
* Respiratory center
* Respiratory muscles, their innervation, neuromuscular junction
* Lung receptors, peripheral and central chemoreceptors
* Lung perfusion, right heart, left heart
* Air pressure and composition

Functions of the respiratory system and processes influenced by its activity:

* **O2 supply**
* **CO2 elimination**
* **Acid-base balance**
* **Enzymatic and endocrine function (ACE)**
* Thermoregulation (inhaled air warming)
* Loss of water
* Energy consumption (work of respiratory muscles)
* Volatile substance elimination (acetone, alcohol...)
* Venous blood filtration (old blood cells, tumor cells, microbes, parasites)
* Blood reservoir for the left ventricle
* Impact on the circulatory system
* Entry of infections and chemical substances (*locus minoris resistentiae*) – 150 m2

**Air, atmosphere**

78 % N2, 21 % O2, 0.04 % CO2, water vapor, noble gasses, pollutants

Altitude sickness, decompression sickness, barotrauma – see etiologic factors of diseases

**Basic processes in the lungs necessary for breathing**

1. Ventilation = Exchange of the air between the external environment and the lung alveoli
2. Diffusion = transport of respiratory gases across the alveolar-capillary membrane
3. Lung perfusion = blood flow through the lungs

**Respiratory insufficiency**

= state when breathing (at rest and at normal atmospheric pressure) is not enough to ensure adequate gas exchange in the lungs

→ The respiratory system does not ensure its fundamental functions, i.e. O2 delivery and CO2 elimination → changes of paO2, potentially also paCO2

* **Hypoxemia =** paO2 ˂ 9 (in old people ˂ 8) kPa
* **Hypercapnia** = paCO2 ˃ 6.5 kPa

Respiratory insufficiency (RI) itself is not a disease but a consequence of many diseases and adverse situations (disturbance of any component of the breathing process - ventilation, diffusion, perfusion, breathing control).

For definite diagnosis of RI, determination of its type and severity, examination of blood gasses in the arterial blood and potentially examination of parameters of acid-base balance are necessary.

Consequences and manifestations of RI depend on its severity, duration and speed of development without respect on its particular cause, which may add some other specific symptoms.

**Classification of RI according to paO2 and paCO2:**

* Type I (partial) - hypoxemia without hypercapnia (can be hypocapnia)
* Type II (global) - hypoxemia and hypercapnia (due to hypoventilation)

**According to the speed of RI development:**

* **Acute** - foreign body aspiration, pneumothorax, asthmatic attack...
* **Chronic** - chronic bronchitis, lung fibrosis, kyphoscoliosis...
* Acute worsening of chronic RI

**According to RI severity:**

* **Manifest RI -** dyspnea and paO2 a paCO2 changes in rest
* **Latent RI -** dyspnea and paO2 a paCO2 changes during physical activity that would not induce changes of respiratory gases in healthy people

**According to RI cause:**

* Pulmonary
* Extrapulmonary

**Hypercapnia manifestation**

* Acidosis
* CNS inhibition - narcotic effect (paCO2 13.3 kPa), including suppression of the respiratory center
* Vasodilation - blood pressure decrease, vasodilation in the brain → brain edema
* Decrease of pO2 in the alveoli (oxygen „replaced“ by carbon dioxide)

**Hypocapnia manifestation**

* Alkalosis
* Increased neuromuscular irritability
* Vasoconstriction in the brain

**Hypoxia** (for details see seminary)

1. Hypoxic
2. Anemic
3. Circulatory
4. Histotoxic

**Ventilation disorders**

Spirometry = ventilation examination

Correct and effective ventilation requires:

* free airways
* adequate lung parenchyma volume
* adequate compliance and elasticity of the lungs and chest wall
* normal function of the respiratory center
* respiratory muscles
* their motor innervation

**Restrictive disorders**

* Characterized by reduction in the lung volume
* The hallmark: decreased vital capacity

Examples:

* Lung resection (pneumonectomy)
* Disorders of the chest wall - kyphoscoliosis
* Disorders of the respiratory muscles and their innervation - myasthenia gravis, ALS, muscular dystrophia, respiratory center disorders...
* Changes in the lung parenchyma - lung edema, pneumonia, tumors, fibrosis
* Pleural changes - pleural thickening
* Pneumothorax
* Processes occupying space within the thorax - tumors, effusions

**Obstructive disorders**

* Impaired patency of the airways, increased resistance
* The hallmark: impaired dynamic parameters

Examples:

* Asthma bronchiale
* Bronchitis
* Emphysema
* Advanced bronchiectasis
* Tumors
* Foreign body aspiration
* Goiter

**Combined disorders**

* Frequent
* Signs of both restriction and obstruction

**Disturbances of distribution of ventilation**

- Unequal affection of the lung parenchyma or Airways

→ better ventilation of normal parts of the lungs, reduced ventilation behind the obstruction or in the parts of the lungs with impaired distensibility**.**

- Functional changes are dependent on the extent and severity of the disease and the sensitivity of the test. Symptoms of the obstructive or restrictive disorders do not need to be always striking.

**Disorders of breathing control and pathological breathing**

Changes of frequency and/or depth of breaths

* Arise from: fever, metabolic disorders, psychic disorders, medicaments, drugs, damage of the respiratory center, physical activity
* O2 consumption can increase due to physical activity up to 10 fold

**Eupnea** = normal quiet breathing

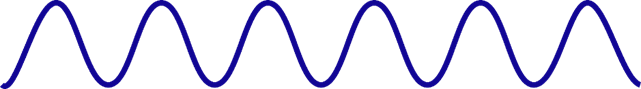
**Apnea**

**Tachypnea (polypnea)** =increased rate of breathing

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**Bradypnea** = decrease rate of breathing

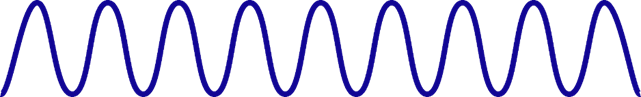


**Hyperventilation** = ventilation increases more than necessary for adequate CO2 elimination → ↓ paCO2

**Hypoventilation** = reduced ventilation, insufficient CO2 elimination → ↑ paCO2



**Hyperpnea** – an increase in the rate and depth of breathing with no impact on paCO2, e.g. during exercise

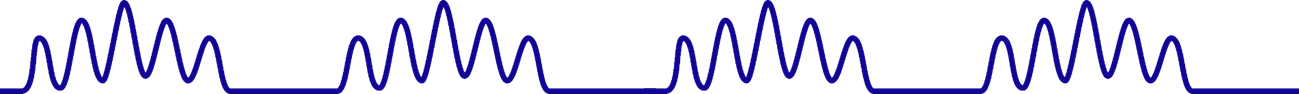
**Kussmaul‘s breathing** - in acidosis

**In decreased irritability or disorder of the respiratory center**

(morphine, respiratory center damage - intoxications, hypoxia, terminal states)

**Slow, periodic breathing:**

* **Chayne-Stokes** - groups of20-30 breathes with increasing and decreasing amplitude and apneic pauses of ½ to ¾ min



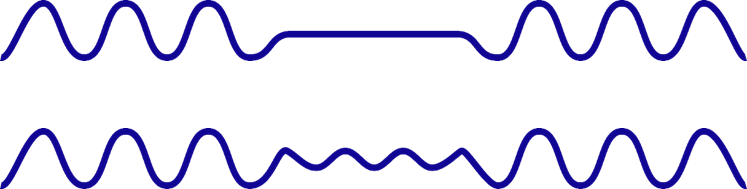
* **Biot´s breathing** - alternation of groups of several breathes with the same amplitude and short pauses, irregular length



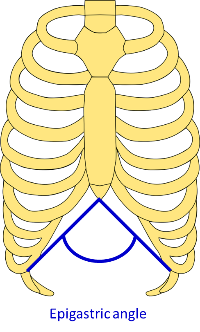
* **Gasping** - breathing with very frequent and forced gasps, regular or irregular, consecutively decreasing intensity

- Manifestation of the activity of the lowest parts of the respiratory centers in terminal states.

* **Apneusis** – convulsive inspiration experimentally evoked by vagotomy, which interrupts the suppressor effect of dthe n. vagus on the respiratory center
* **Sleep apnea syndrome** - affects men more than women and is often associated with obesity and hypertension, but also with snoring. The syndrome is connected with extreme increase of blood pressure and can cause mainly in people with cardiac diseases.



* **SIDS (Sudden Infant Death Syndrome)** – suckling death during the sleep due to immaturity of neural connections within the brain stem (more frequent in smoking mothers → passive smoking of suckling).

**Thorax**

**Sthenic thorax**

* symmetric, normal shape
* epigastric angle = 90 °

**Asthenic chest**

* long, flat, ribs obliquely down
* sharp epigastric angle
* a part of the „phthisic habitus“
* disposition to lung TBC

- due to preliminary ossification of the 1st rib and insufficient ventilation of the apical parts of the lungs, but also due to the general neurohumoral constitution

**Barrel chest**

* large dorsoventral dimension, obtuse epigastric angle
* pyknic type, characteristic for the emphysema
* small ventilation movements, the chest in inspiration position - expiratory dyspnea

**Kyphoscoliotic chest**

* pathology, ventilation movements are asymmetric, significantly reduced
* after some time disorder of lung perfusion develops - increased resistance, pulmonary hypertension

**Thorax pyriformis**

* narrowed inferior part of the chest, chest breathing, poor ventilation of basal parts of the lungs

**Pectus carinatum**

* prominent sternum, a consequence of the rickets

**Pectus excavatum**

* inferior part of the sternum is impressed inside

**Diffusion disorders**

**Diffusion** = movement of molecules from a compartment with higher concentration to a compartment with lower concentration, tendency to eliminate differences in concentration within the various regions

- A passive process (Brown’s motion of particles), no need of energy

In the lungs, O2 moves from alveolar gas into capillary blood, CO2 moves from the blood into the alveoli.

In the peripheral tissues, O2 moves from the capillary blood into the interstitial space and into the cells, CO2 moves from the cells into the capillaries.

**Diffusion capacity of the lungs (DC)** – amount of gas that moves across the alveolar-capillary membrane within a time unit due to different partial pressure of the gas (pressure gradient).

D...diffusion

k....coefficient, characterizing properties of the substance and the membrane (e.g. solubility, particle size, pore diameter...)

∆P...gas pressure gradient

S...diffusion membrane area

l...diffusion trajectory (alveolar-capillary membrane)

**Increase of DC** - increased volume (flow) of the blood in the lung capillaries

**Reduction of DC** - reduction of volume (flow) of the blood in the lung capillaries

- alveolar-capillary block

- reduction of diffusion area (elimination of part of the lungs)

**Diffusion reduction**

* Reduction of diffusion area of the lungs - restrictive disorders (lung resection, emphysema, thorax deformities, pneumothorax...)
* Decrease of alveolar-capillary gradient, changed V/Q ratio

- restrictive and obstructive disorders

- changes of lung perfusion

* Thickening of the alveolar-capillary membrane - lung edema, pneumonia, ARDS, fibrosis

**Time of the contact of the blood with the alveoli**

Normally, full blood saturation with O2 within 1/3 of the contact duration

In diffusion disorders, increased blood flow speed (fewer, anemia, exercise), i.e. contact shortening, can play a role.

**Perfusion disorders**

Pulmonary perfusion - delivery of venous blood to the alveoli and drainage of oxygenated blood to the left heart

Physiologically unequal perfusion of various parts of the lungs (↑ at the bottom)

* Together with unequal ventilation → differences in sensitivity to diseases

**Regional regulation of lung perfusion**

* Secondary vasoconstriction induced by hypoxia

→ Redistribution of perfusion into more ventilated parts of the lungs and maintenance of V/Q

→ But: increase of pulmonary circulation resistance in the case of generalized alveolar hypoxia

**Disorders of perfusion and its distribution in the lungs**

* Diseases of the pulmonary vessels (pulmonary embolism, vasculitis, emphysema)
* Vessel compression (tumors, cysts)
* Secondary vasoconstriction in local ventilation impairment
* Blocked drainage of the blood from the lungs

**Relation between ventilation and perfusion**

Normal ventilation/perfusion quotient V/Q = 0.8 at resting

(alveolar ventilation 4 l/min, perfusion 5 l of blood/min)

**Hypoventilation disorder:** V/Q ˂ 0.8

**Hypoperfusion:** V/Q ˃ 0.8

**No perfusion:** V/Q infinite

**No ventilation:** V/Q = 0

**Disorders of nutrition circulation of the lungs**

- rare

**Pulmonary infarction**

* Only in the case of affection of both nutrition and functional circulation
* Necrosis of affected part of the lung + complications (inflammation)

**Pulmonary hypertension**

= Increased resistance of the pulmonary circulation

The driving force of the blood flow in the pulmonary vascular bed is pressure generated right ventricular systole.

* **Systolic pressure in the right ventricle and the pulmonary artery** is only about 1/5 of blood pressure in the left ventricle and aorta, i.e. 25 torr (3.33 kPa).
* **The pressure gradient from the right ventricle to the lungs and to the left atrium:** 10 torr (1.33 kPa)

- Pulmonary resistance must be low enough for transport of the contents of the right to the left ventricle within 0.8 s.

* Pulmonary vascular bed resistance can further decrease due to vasodilation and opening of unperfused capillaries. Therefore, during working even when the pulmonary blood flow increases, the blood pressure in the RV and pulmonary artery increases only slightly (in healthy young individuals).

Therefore, in a young person, a branch of the pulmonary artery may be ligated or pulmonectomy may be performed without the risk of increased pulmonary pressure (e.g. twice), as would be expected from the reduction of the pulmonary vascular bed cross-section in half.

Under pathological conditions and in elderly declining distensibility of the pulmonary vascular bed and the number of capillaries decrease.

Therefore, before pulmonectomy in patients or old people, a balloon catheter must be first introduced into the branch of pulmonary artery, which leads to the lung lobe that should be removed. The balloon catheter is then inflated to obturate the branch.

Only when the pressure in the pulmonary artery does not increases after the obstruction above 40 mm Hg (5.33 kPa), the pulmonectomy can be performed without danger of failing PK for pulmonary hypertension.

**Causes of pulmonary hypertension**

1. Precapillary
2. Capillary
3. Postcapillary

* Mitral stenosis, left heart insufficiency
* Pulmonary emphysema - resistance increases due to reduction of the alveolar capillaries, decreased lung tissue elasticity and hypoxemia
* Diffuse lung fibrosis, TBC, pneumoconiosis, COPD - similarly like in the emphysema
* Pulmonary embolism
* Sclerosis or thrombosis of the pulmonary vessels - rare
* Compression of pulmonary vessels

**Consequences of pulmonary hypertension**

Slow development of pulmonary hypertension

* Adaptation of the right ventricle - hypertrophy, later dilatation, right ventricle failure

→ **cor pulmonale chronicum**

Suddenly occurring pulmonary hypertension → **cor pulmonale acutum**

Increased hydrostatic pressure in the lung capillaries

- At an obstacle behind the capillaries (e.g. left heart failure)

* Normal hydrostatic pressure in the lung capillaries 10/5 torr (1.3/0.65 kPa) 4 fold lower than in the systemic circulation capillaries
* Oncotic pressure of the plasma is the same, i.e. 25 torr (3.33 kPa)
* This pressure exceeds significantly filtration pressure in the lung capillaries and protects the lung against transudation
* In severe hydrostatic pressure increase → transudation, lung edema

**Pulmonary embolism**

* Obstruction of pulmonary vessels by corpuscles carried by the venous blood
* Embolization of a thrombus - the most frequent (mostly from the lower extremities of pelvic plexus) - thromboembolic disease
* Air embolism - more than 40 ml of air
* Fat embolism - in multiple fractures
* Reduction of lung perfusion with preserved ventilation (increased dead space)
* Respiratory insufficiency, usually type I, hypocapnia can occur due to tachypnea

Massive pulmonary embolism

* Sudden increase pulmonary resistance, acute overload of the right ventricle

**= cor pulmonale acutum**

* Sudden dyspnea, chest pain, tachypnea, tachycardia, central cyanosis, manifestations of acute right heart failure
* Drop of cardiac output → hypotension or even cardiogenic shock

Successive pulmonary embolism

- Repetitive small embolizations → **cor pulmonale chronicum**

**Protective respiratory reflexes**

**Apneic reflex** = breathing stop after nasal receptor (n. trigeminus) irritation with strong pungent odor in inspired air (e.g. ammonia)

**Strong and explosive expiration:**

Sneeze reflex - cleaning of the oropharynx after irritation of nasal receptors

Cough reflex - a protective reflex cleaning tracheobronchial airways triggered by irritation of:

- the pleura, larynx, trachea, bronchi

- distant organs (liver, spleen, uterus, eye, tympanic membrane)

Irritation of the lung tissue itself does not cause coughing!

**Pathophysiology of respiratory disease symptoms**

* cough (including expectoration, potentially with admixture of blood)
* chest pain
* dyspnea
* nail cubing

**Cough**

In healthy people, cough is rare. The mucocilliary system carries up their bronchial secretions into the pharynx, after that, it is swallowed.

Coughing is one of essential mechanisms protecting the airways from the averse effects of inhaled noxious substance and also serves to clear them of retained secretions

Mechanism: – coughing may be produced voluntarily or reflexively due to stimulation of:

* Extrathoracic cough receptors - nose, oropharynx, larynx, upper trachea
* Intrathoracic rapidly adapting irritant receptors - epithelium of the lower trachea and large central bronchi

Afferent pathway: trigeminal, glossopharyngeal, superior laryngeal, or vagal nerve

The pressure in the pleural space is higher than the luminal pressure in the trachea and central bronchi

→ Dorsal membranous portion of the airway walls is drawn inward and nearly obliterates the lumen.

During cough, the **volume flow** (l/s) is only slightly greater or the same as it is during a forced expiratory maneuver.

**Linear speed** of airflow through the narrowed channels is markedly increased (at the level of the glottis 120 - 130 m/s)

Productive (wet) cough

- should not be suppressed by medicaments, because it clears retained secretions from the airways.

Unconscious or intubated patients must have their tracheobronchial secretions removed by suctioning.

Nonproductive (dry) cough

- should be suppressed, it is an exhausting irritative phenomenon

Alteration of the surface epithelium of the large airways sensitizes its receptors; thus, the cough reflex becomes hyperactive.

Chronic cough: The most frequent cause is the bronchial asthma.

An intractable, dry cough can be also side effect of some medicaments (e.g. angiotensin – converting enzyme inhibitors).

Cough complications

* Exhaustion
* Heart syncope

Unclear mechanism, probably more factors

- Increased intrathoracic pressure reduces venous return → decreased brain perfusion

* Coughing seems to provoke more coughing attacks - typical for pertussis
* Vomiting
* Fractures of ribs (cough fractures) and even compression fractures of vertebral bodies
* Internal pneumothorax - if bullous emphysema is present, rupture of a bulla

**Chest pain**

Broad spectrum of diseases, not only the respiratory system - dif. dg.!

* Pleural pain - pleuritis, tumors, injuries

- Restricted in distribution rather than diffuse, mostly unilateral, tends to be distributed along the intercostal nerve zones.

- Typically related to breathing movements

→ increased by cough

→ prevents deep breathing

- Pain from diaphragmatic pleurisy is often referred to the shoulder and side of the neck.

* Respiratory system inflammations
* Pulmonary embolism

**Dyspnea**

= breathlessness = breathing discomfort, lack of air, difficulty in breathing

Dyspnea is pathological if occurring at resting or during mild physical activity.

Dyspnea deals with stimulation of receptors related too breathing:

* intrapulmonary
* in the muscles and tendons of the respiratory muscles
* chemoreceptors in the arteries and brain
* Subjective feeling of lack of air is caused by
* discrepancy between tension and length of muscle fibers in the respiratory muscles and inadequate level of respiratory gas exchange
* stimulation of central and peripheral chemoreceptors (decreased pH and paO2 and increased paCO2)
* stimulation of intrapulmonary receptors (e.g. in lung edema or microembolization)

Fatigue of the respiratory muscles, reduced respiratory reserve and negative emotions (fear, anxiety) also contribute to dyspnea.

Types of dyspnea

Inspiratory and expiratory dyspnea

Dyspnea in resting state, dyspnea during activity

Types of dyspnea according to its origin

* stenotic (inspiratory or expiratory) - functional (bronchospasm, laryngospasm) or anatomic obstacles in the airways
* pulmonary - reduction of diffusion area or permeability of the membrane
* cardiac (asthma cardiale) - left heart failure
* acidotic - acidosis
* anemic - severe anemia, during activity, lack of oxygen in the tissues
* psychogenic

Orthopnea = forced breathing in sitting position, the body supported with the arms, shoulder elevation, open mouth, use of auxiliary muscles

Platypnea = dyspnea that occurs in the upright position (some heart defects)

Trepopnea = dyspnea occurring when lying on one side, cardiac congestion, unilateral respiratory disorders

**Nail cubbing**

* specific bulbous enlargement of the end of fingers (similar to drumsticks)
* a sign of chronic hypoxemia

**Pulmonary edema**

Interstitial

Alveolar

**Cardiogenic pulmonary edema**

* When blood pressure in lung capillaries exceeds the level of 25 torr (3.33 kPa = oncotic pressure of the plasma)
* Transudation of fluid into the interstitium or later also into the alveoli

**Toxic pulmonary edema, inflammation**

* Injury of alveolar-capillary membrane (inhalation of toxic gas, allergens...)
* Exudation

**Consequences**

impairment of oxygen diffusion

restrictive ventilation disorder, reduction of lung compliance, reduction of alveolar space

hypoxemia, often hypocapnia

dyspnea

**ARDS**

= adult respiratory distress syndrome

= acute respiratory distress syndrome

Very serious acute states of diverse etiologies, characterized by diffuse infiltrative lung lesions with very severe arterial hypoxia in adults.

Similarly in neonates - X primarily the immaturity in alveolar surfactant production

In ARDS the changes concerning surfactant are secondary.

ARDS → MOSF (multiple organ system failure)

or

MOSF → ARDS

**Conditions and states associated with ARDS and MOSF**

* Sepsis syndrome
* DIC
* Severe trauma
* Diffuse pneumonia
* Pulmonary embolism
* Inhalation of toxic substances, stomach content, water during drowning
* Long-term oxygen inhalation
* Burns and smoke inhalation
* Multiple transfusions
* Pancreatitis
* Anaphylaxis
* Drug overdose
* Cardiorespiratory arrest

**In the ARDS of any etiology, fluid volume in the lungs is always increased, but**

* no cardiopulmonary edema is present at the beginning
* the pressure in the pulmonary capillaries in ARDS is not elevated
* the permeability of the alveolar-capillary membranes is increased
* consequence of primary (inflammation, toxins) or secondary damage by activation and aggregation of blood elements inside the pulmonary capillaries.

**Pathogenesis of ARDS**

* Aggregation of thrombocytes, monocytes and polymorphonuclear leukocytes adhere to endothelial surface.
* Induction of an inflammatory reaction and release of inflammatory mediators e.g. leukotrienes, thromboxane, and prostaglandins.
* Alveolar macrophages release oxidants, mediators, and a series of degrading enzymes and peptides, which damage directly the endothelial and alveolar surface.
* The lesions of alveolar membranes lead to the leak of fluid with macromolecules and cellular particles from the capillaries into the interstitium.
* Increased permeability of capillaries for proteins facilitates the development of pulmonary edema.
* The damage of pneumocytes in the alveoli impairs the production of surfactant
* Presence of fluid and fibrinogen in the alveoli lead to their collapse.
* → restrictive ventilation disorder
* Clinical manifestation of ARDS includes increased frequency of breathing, arteria hypoxemia and dyspnea.

The mortality in patients with ARDS or with conditions called shock is very high.

In the past almost 100%, now about 50-60%.

In favorable cases the recovery lasts 4-6 months.

Risk of lung fibrosis.

**Chronic obstructive pulmonary disease - COPD**

A group of diseases characterized by permanent decrease of expiratory flow speed

* chronic bronchitis
* emphysema

Usually, combination of both

Narrowing of the airways is caused by:

* inflammation (hypersecretion, mucous membrane hypertrophy)
* collapse due to damage of the wall and loss of extending power of the surrounding lung parenchyma

**Chronic bronchitis**

The most frequent cause = smoking

Ventilation-perfusion imbalance → hypoxemia → vasoconstriction in the lungs → pulmonary hypertension

Reduction of ventilation → hypercapnia, respiratory acidosis

**Pulmonary emphysema**

= A chronic respiratory disease due to primarily obstructive disorder with loss of interalveolar septa together with capillaries.

Etiology and pathogenesis

Chronic inflammation, reactive oxygen species, elastase, collagenase, metalloprotease activation, hereditary α1-antitrypsin deficiency, smoking, overpressure

Consequences

* lung capillary bed is significantly smaller than normally
* pulmonary hypertension, overload and failure of the right heart ventricle

**Asthma bronchiale**

- a clinical syndrome characterized by recurrent episodes of airways obstruction, hypersensitivity and hyperreactivity

Etiology not uniform and unclear

**Pathogenesis**

* Allergy - attacks induced by allergens
* Hypersensitivity - other triggering factors (smoke, cold air...)
* Mediators: histamine, acetylcholine, kinins, adenosine, leukotrienes, PAF (platelet-activating factor), tachykinins
* psychosomatic mechanisms

**Obstruction mechanisms**

* Constriction of bronchial smooth muscles
* Edema of the bronchial mucous membrane
* Bronchial hypersecretion - viscous secret with eosinophils

Obstruction of small bronchi and bronchioli

→ expiratory dyspnea, sound phenomena during expirium

Between the attacks no problems

But: After some time thickening of the bronchial wall can develop due to repetitive inflammation → permanent obstruction

**Pulmonary fibrosis**

= proliferation of fibrous tissue in the lung parenchyma

**Causes**

* pneumoconiosis, interstitial pneumonia
* sarcoidosis
* irradiation
* toxic gasses, aspiration pneumonia
* ARDS
* idiopathic

**Pathogenesis**

* inflammation of the interstitium, proliferation of fibroblasts, production of collagen and fibronectin

**Consequences**

* reduction of lung compliance → difficult lung distension → restrictive disorder
* elongation of diffusion trajectory
* dyspnea, partial respiratory insufficiency, later global
* pulmonary hypertension - due to hypoxia

**Pneumoconiosis**

= Deposition of solid inorganic corpuscles in the lungs

Clinical symptoms depend on:

1) an individual organism response to inhaled dust

2) the quality of the inhaled dust

3) its concentration in inhaled air

4) duration of exposure

Particles smaller than 3μ are inhaled into the alveoli, wile larger ones are retained in the upper airways and removed by the mucocilliary system.

Pneumoconiosis can be prevented by adequate technology (air filtration, face masks, etc.).

**Asbestosis**

- inhalation of asbestos fibers

- irritation of lung tissue → fibrosis, cancer

**Silicosis**

- inhalation of silica (SiO2)

- phagocytosis, particles smaller than 0.5 μ induce inflammation like pneumonia

- hyaline fibrotic nodules

- risk of secondary infection (e.g. silicotuberculosis)

**Anthracosis**

- coal dust

- chronic bronchitis, usually no massive fibrosis if there are no silica particles

**Metal pneumoconioses, siderosis**

**Hyperoxia**

= consequence of breathing pure O2 (or O2 in high concentration - 80%), especially for a long time

- inflammatory changes in the lungs similar to pulmonary edema

Breathing O2 at a pressure higher than 1 atm

- symptoms similar to NS anoxemia (oxygen toxicity)

At a pressure of 3-4, atm O2 dissolved freely in the blood is enough to supply the tissues

→ HbO2 is not dissociated → Hb cannot bind CO2 → poisoning with CO2 despite sufficient amount of oxygen

**Bronchiectasis**

= irreversible dilatation of the bronchi of medium and small diameter

- combined with inflammation of the bronchial wall

**Development**

* weakness of the bronchial wall - hereditary defects of the fibrous tissue, inflammations
* increased intrabronchial pressure
* external traction
* ciliary system dysfunction

Secret retention in the bronchiectasis → infections

**Complications**

* repetitive inflammations
* hemoptysis
* hypoxemia
* pulmonary hypertension

**Cystic fibrosis**

= autosomal recessive hereditary disease

- mutation in the gene encoding CFTR (cystic fibrosis transmembrane conductance regulator)

- Cl- channel and regulator of conductivity of other ion channels

- viscous secretions, increased secretion of Cl- by sweat glands

- obstruction of pancreatic ducts → cystic fibrosis of the pancreas

- viscous secretions in the lungs → recurrent infections, bronchiectasis, consecutive development of chronicle respiratory insufficiency

**Pathophysiology of the pleural cavity**

**Pleuritis**

**Tumors**

**Pathologic content of the pleural cavity** → collapse or compression of the lung

* **Serous exudate** - typical for serous pleuritis, tuberculosis and rheumatoid polyserositis
* **Bloody exudate** - lung or pleural neoplasm, injuries
* **Purulent exudate** - secondary infection serous exudate
* **Hemothorax**

- accumulation of blood in the pleural cavity, mostly due to an injury.

After resorption of pleural effusions or organization of the hematoma adhesions often remain → restriction of ventilation

**Pneumothorax**

= the presence of air in the pleural cavity, lung collapse

* Unilateral, bilateral
* According to the cause: spontaneous, traumatic, artificial
* External, internal

Closed pneumothorax

- transient communication, influx of certain amount of air into the pleural cavity

- severity determined by the air amount

Open pneumothorax

- permanent communication, the air can move in as well as out

- lung collapse can be complete, worsened breathing as well as circulation

- Therapy: closing the communication, drainage of the air

Tension pneumothorax

- The opening acts as a valve, influx of air during inspirium, obstruction of the communication during expirium

→ air accumulation, ↑ pressure, deviation of the mediastinum and compression of the contralateral lung → the most severe form

**Altitude (mountain) sickness**

↑ altitude → ↓ atmospheric pressure → ↓ pO2

→ hypoxic hypoxia

Manifestations:

headache, dizziness, fatigue, sleepiness, euphoria when the output is above 2000 m.

In healthy people, distinct unpleasant symptoms occur in up to an altitude of about 4000 m. This height is called „border of integrity“. By further ascent to altitude, particularly in untrained and altitude-unadapted individuals can cause coma or death.

**Smoking**

- one of the most important etiopathogenetic factors.

At least, 25 serious illnesses arise as a direct consequence of this bad habit and many other pathological states develop because of negatively influenced reactivity of the organism.

Nicotine dependence is a case of the hard drug type abuse.

Also, passive smoking is dangerous.

Respiratory diseases, immunity disorders, tumors, atherosclerosis

Worldwide, smoking is the cause of death in 15 % of men and 7% of women.

Lifelong smoking shortens the length of life by an average of 15 years.