

# Larynx and trachea

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## Adenotomy

It is a removal of adenoids (pathologically changed pharyngeal tonsils). At present, it is made in general anaesthesia, which leads to a decreasing number of complications (bleeding) and repeated operations. Indication for adenotomy is a pathology of the pharyngeal tonsil (hypertrophy, inflammation)

## Tonsillectomy

It is a total removal of palate tonsils. Most frequent indications are:

1. recurrent acute tonsillitis
2. chronic tonsillitis (according to the patient's problems)
3. palate tonsils hypertrophy by chronic inflammation or by repeated acute inflammations in history
4. complication of tonsillitis
5. tumor of oral cavity or pharynx (extended tonsillectomy)
6. complete lateral neck fistula from 2. branchial arch (unilateral tonsillectomy)

## Tonsillotomy

It is partial removal of palate tonsils. Indication is an obstructive sleep apnea syndrome (OSAS) caused by the hypertrophy of the palate tonsils. There must not be present any other pathologies of tonsils.

## Comments on embryology of larynx and trachea

Larynx evolves from the cranial end of the laryngotracheal tube which develops from sacciformis evagination on the ventral part of the ventral gut. Embryonic aditus laryngis has a T-shape (at the end of the 1<sup>st</sup> month). The inner part of the larynx merges together by entoderm proliferation. Larynx is recanalizing because of cells destruction in the central part of the tube. Laterally, there are formed slit shaped basics of ventriculus laryngis. Upper edge if those slits change into plicae ventricularesm; lower edge into plicae vocales.

Cartilages and muscles of the larynx develop from the 4<sup>th</sup> and 5<sup>th</sup> branchial arch. Muscles are innervated by n.X.

Larynx is formed cranially and later descends caudally. In the 5<sup>th</sup> foetal month, it is in the level of nasopharynx. Neonates have the epiglottis in the level of the 2<sup>nd</sup>-3<sup>rd</sup> neck spondyl, adults in the 5<sup>th</sup> neck spondyl. The growth is faster during pubescence, especially in boys.

Trachea evolves from the laryngotracheal tube after the larynx. Cartilages differentiate in 2<sup>nd</sup> month. The laryngotracheal tube has a dead end with a button-like bronchopulmonal entodermal evagination. Lungs and bronchi are formed from it.

## Clinical anatomy of larynx and trachea

### Clinical anatomy of larynx

Neonates have a small and wide larynx. Average diameter in adults is 5 cm in women and 7 cm in men. This difference causes different voices in women and men. Vocal cords lengthen by 3 mm in girls and 5-10 mm in boys during pubescence. Lengthening of vocal cords causes mutation voice disorders. Larynx has a final size at 23 years of age. Voice aging is present around 60<sup>th</sup> year of age (calcification of cartilages), voice range and volume is decreased, voice color is sharper.

Larynx is located on the ventral part of the neck and its ventral part is covered by caudal muscles of the hyoid bone (infrahyoid muscles) and by both leafs of infrahyoid fascia. On the lateral walls, there are lobes of the thyroid gland. Behind the larynx there is hypopharynx. Ventrocranially, there is the hyoid bone and tongue. Caudally, it continues as a trachea. The laryngeal wall consists of cartilages connected by fibrous tissue and joints. On their frontal, lateral and dorsal walls, there are muscles which move the cartilages and control tension and distance of vocal ligaments. Larynx is covered with ciliary epithelium, its cilia oscillate towards the entrance. On vocal ligaments and epiglottis, there is spinocellular epithelium. In mucosa, there are small glands. Lymphatic tissue is abundant, especially on the ventral part of the epiglottis and in ventriculus laryngis. Submucous fibrous tissues are thin so that infection can cause edema and resulting dangerous stricture of larynx interior.

### Laryngeal skeleton

Contains 3 unpaired cartilages and 2 paired.

- **cartilago thyreoidea** – has a right and left leaf
- **cartilago cricoidea** – supporting laryngeal cartilage.
- **Epiglottis**
- **Cartilagine arytenoides** – are connected by joint with the upper part of annular cartilage. Ligamentum and muscle of vocal cord are bound to processus vocalis (ventral processus). Arytenoid cartilage is moving and causes dilatation and closure of vocal cords fissure, which is called glottis

### **Cavum laryngis**

- **supraglottis:** contains all anatomic structures above the vocal cords (laryngeal part of the epiglottis, aryepiglottic plicae, ventricular plicae, sinus Morgagni, arytenoid area)
- **glottis:** vocal cords
- **subglottis:** area under the vocal cords, continuing to the trachea

### **Muscles of larynx**

They are striated muscles, richly innervated and localized around the larynx in 3 groups:

#### **Ventral:**

- **M.cricothyreoideus** draws cartilago thyreoidea to the annular cartilage. It causes tension of ligamenta vocalia.

#### **Dorsal:**

- **M.cricoarytenoideus dorsalis** (posticus) – it draws processus muscularis cartilaginis arytenoidei medially and causes tension of vocal ligaments – abductor of vocal ligaments
- **M.arytenoideus** (transversus) – adductor of vocal ligaments
- **M.aryepiglotticus** – it bends epiglottis forward

#### **Lateral:** sphincters of glottis

- **M.cricoarytenoideus lateralis** – antagonist of similar dorsal muscle:
- **M.cricoarytenoideus dorsalis**

- **M.thyreoarytenoideus** has an external part (pars lateralis) and an inner part (pars vocalis - m.vocalis). It is localized in plica vocalis. It is the antagonist of m.cricothyreoideus
- **M.thyreoepiglotticus** – same function as m.aryepiglotticus

### Vascularization of larynx

- a.laryngea superior from a.thyreoidea superior
- a.laryngea inferior from a.thyreoidea inferior
- veins are called similarly
- lymphatic vessels drain lymph from deep neck lymphatic nodes.

### Innervation of larynx

- **motoric:** n.laryngeus inferior (n.recurrens) from n.X. On the right side goes under a.subclavia dx. and goes up between trachea and esophagus to the larynx. On the left side this nerve is lower, goes under aortal arch and goes alongside the trachea to the larynx. The right one is shorter than the left one. The only exception is m.cricothyreoideus, it is innerved from n.laryngeus superior (branch of n.X as well)
- **sensitive:** n.laryngeus superior

### Physiology of larynx

- **Respiratory function:** the larynx maintains the flow of the passing air. During breathing the glottis is free and has a triangular shape. During inspiration it is slightly wider, during expiration slightly narrower. The velocity of the air is 3-5 m/sec, during screaming it is 30-40 m/sec.
- **Phonatory function:** the human voice is formed by periodic oscillation of the air column above the vocal cords. The primary tone is formed by opening and closing the glottis due to air pressure changes. Speech cavities are: nasal cavity (its shape does not change), pharyngeal cavity (its shape changes and plays role in speech sounds formation). The main role in speech sound formation is played by the oral cavity, its shape can be easily changed. Voice and speech is communication controlled by hearing that is why hearing disorders are followed by speech disorders.
- **Protective function:** maintained by muscles and laryngeal mucosa. Lymphatic tissue in larynx has a similar function as in the pharynx. Glands produce mucus and ciliary transport is responsible for the transport of mucus and small foreign bodies towards the oral cavity. Protective reflexes (cough and swallowing) are controlled by n.X. Cough reflex is caused by an irritation of the sensitive part of n.X in larynx, pharynx

and trachea. It helps to clean not only the larynx itself, but the whole tracheobronchial tree as well and helps to remove foreign bodies.

During swallowing, the larynx protects the lower airways. It prevents the intrusion of food to the lower airways by coordinated movements of muscles of larynx, the oral cavity and the tongue. During swallowing, the larynx is moving proximally and radix linguae dorsally.

### **Clinical anatomy of tracheobronchial tree**

**Trachea** is a tube connected cranially with the larynx. Ligamentum cricotracheale binds it to the annular cartilage. Trachea begins on the level of C6 and ends on the level of Th 4-5 as a bifurcatio tracheale – bronchus dexter and sinister. Carina tracheae is a sagittal horizontal edge protruding in the bifurcation into the tracheal interior. In the walls of trachea there are approx. 15 hyallinous cartilages – cartilagine tracheales. They look like horseshoe and are open dorsally. Dorsal part – pars membranaceus is formed by collagenous and elastic fibrils and smooth muscles. Cartilages are connected together by ligamenta annularia

**Mucosa** is pink with longitudinal plicae in paries membranaceus. It is covered by ciliary epithelium. In epithelium, there are many calyciform cells. Submucous tissue is thin and contains many glandulae tracheales. Adventitia connects trachea with esophagus and bind it to the surrounding structures.

**Bronchi** is name for branched system of tubes leading the air form the trachea into the lungs

- **Bronchi principales** (main) are two: left and right. They begin in the bifurcation tracheae. Right bronchus is shorter, wider and more straight than the left one.
- **Bronchi lobares:** lobe bronchi (superior, medius, inferior dexter and superio, inferior sinister)
- **Bronchi segmentales:** branches of lobar bronchi
- **Bronchioli:** branches of smallest bronchi, bronchioli terminales

### **Vascularization and innervation**

- Arteries: rr.tracheales from a.thyreoidea inferior and rr.bronchiales from thoracic aorta
- Veins of trachea bring blood into esophageal veins, v.thyreoideae inferiores and vv.brachicephalicae
- Lymphatic vessels lead to nodi tracheales and tracheobronchiales superiores, dexter and sinister, after that to the truncus bronchomediastinalis dexter and sinister
- Nerves are from n.X and neck sympaticus

## Physiology of tracheobronchial tree

Air passes through the upper and lower airways. The pulmonary artery goes alongside the bronchial tree, so the smallest arteries go together with terminal bronchioli. Arterioles accompany bronchioli respiratorii and capillaries spins around the alveoli in the form of nets. Capillaries are in the interstitium of the alveolar septum and are tightly connected with lamina basalis of the alveolar epithelium. Oxygen goes from the alveolar air into capillaries and CO<sub>2</sub> goes from capillaries into the alveoli. On the inner parts, there are located alveolar macrophages – dust cells, which contains phagocytated dust particles and together with macrophages inside interstitium form defense against infections. Secretory pneumocytes form surfactant, which decreases surface tension and prevents collapse of alveoli – pulmonary atelectasis.

## Examination methods of larynx and trachea

### Inspection, palpation

With sight, we examine the ventral part of the neck and with palpation during swallowing, speaking and in rest.

### Laryngoscopy

- **indirect:** by laryngoscopic mirror or by magnifying optical laryngoscope. The picture is vertically reversed.
- **Direct:** by rigid tube and microscope (for endoscopic surgery) or by flexible laryngoscope. The picture is horizontally reversed.

Laryngoscopy serves for the examination of anatomic changes in the larynx and of the function of the laryngeal interior. Patients must say eee or iii during examination. A special case is the examination of correct phonation with the help of the stroboscopic light.

### Examination of tracheobronchial tree

- **history:** dominant symptoms are dyspnea, cough, hoarseness, stridor, swallowing problems, odynophagia. We must find out time of the beginning, frequency and intensity.
- **Physical examination:** auscultation, functional pulmonary tests (tidal volume, residual volume, Total lung capacity (TLC), Forced vital capacity, Functional residual capacity, Forced expiratory volume at 1 second, The ratio of forced expiratory volume at 1 second to forced vital capacity), polysomnography (EMG, EEG, EKG, electrooculography, nasal and oral airflow, respiratory movements and effort, saturation, position during sleeping).
- **Imaging methods:**

- **X-ray:** a ventral and lateral picture is necessary for screening in suspicion of airways diseases. A lateral picture can be made in expirium or inspirium. X-ray is suitable for diagnostics of pathology in the retropharyngeal space (infection, abscess, tumor). Subglottic or tracheal stenosis can be seen on the X-ray. Epiglottic edema can be seen on the lateral picture. A normal picture is suitable for the identification of foreign bodies. We can see contrast bodies, non-contrast can cause an obstruction or stricture in airways
  - **Fluoroscopy:** it is used for diagnostics of sleep apnea syndrome
  - **Contrast radiography:** X-ray with the help of contrast fluid. It is used for diagnostics of GERD, aspiration, tracheoesophageal fistula or foreign bodies.
  - **Arteriography:** used for the detection of great vessels anomalies or vascular tumors
  - **CT:** in axial and coronary projection. CT is a method of choice in case of injuries, congenital abnormalities, tumors and foreign bodies. CT with contrast helps us to find vascular lesions, abscesses, etc. Disadvantages are higher price, irradiation, static picture. Ultrafast CT allows dynamic examination of airways
  - **Virtual bronchoscopy:** is used in severely ill patients, in case of coagulopathy, for diagnostics of tumors, chronic foreign body, etc. It is a non-invasive method without need of general anaesthesia. It is 3D reconstruction of CT scans (1mm thickness). Examination can be made with contrast fluid (tumors, extraluminal pathology). For diagnostics of tracheomalacia or airways collapse can be used dynamic inspiratory-expiratory imaging.
  - **MRI:** has same advantages as a CT. It does not irradiate the patient and can display anatomic structures in many different levels, has an excellent resolution. It is not suitable for bones examination, CT is much better.
  - **Ultrasonography (USG):** suitable for examination of solid formations, cysts, abscesses, lymphadenopathies, which can cause strictures of airways. In last few years there has been high frequency endoluminal USG.
- **Nuclear methods:** especially for diagnostics of tumors (SPECT, PET)
    - **Bronchoscopy:** endoscopic examination of trachea and bronchial tree. We can divide bronchoscopy into rigid and flexible. Bronchoscopy can be diagnostic or therapeutic.
    - **Rigid bronchoscopy:** it is performed in general anaesthesia. Rigid tube is inserted through the mouth, the patient is lying on the back. Orientation points are uvula and epiglottis. We can see glottis and after insertion of the tube between the vocal cords we can see the trachea and branching of the bronchial tree. The patient is intubated by bronchoscope and simultaneously the operation is performed (foreign body removal, stenosis dilatation, partial dissection of tumor). Foreign bodies are removed only by rigid bronchoscopy in general anaesthesia.
    - **Flexible bronchoscopy:** used for diagnostics of tracheobronchial tree diseases. In children, it is performed in general anaesthesia. The tube can be inserted via the mouth or the nose. Orientation points are the same as in rigid bronchoscopy. If we find any pathology, we can do diagnostic procedures – biopsy, irrigation, aspiration, abrasion, etc.)

## Congenital defects of larynx and trachea

Early diagnostics of congenital defects is a condition of early curative surgery and even life salvation. Congenital defects are diagnosed according to phonation and respiratory dysfunction. Essential are laryngoscopy, X-ray, CT and pediatric examination.

### Stridor laryngis congenitus

**Definition:** temporary stridor in children, caused by laryngomalacia

**Etiology:** congenital defect, caused by hypoplastic ligaments of sucklings larynx and epiglottic cartilage (laryngomalacia).

**Pathogenesis:** during inspiration the supraglottic structures are sucked in the laryngeal interior and distinct inspiratory stridor is present, expiration is silent, voice is plain. The epiglottis is tipped over the larynx entrance by the flow of the expired air. By this mechanism the laryngeal interior is narrow and the air which goes through this slot causes inspiratory stridor.

**Symptoms:** inspiratory stridor, during crying or cough it is stronger, by the change of position it can be reduced. The strongest symptoms are immediately after the birth, after that they will subsequently and spontaneously diminish.

**Diagnostics:** history, laryngoscopy

**Therapy:** symptomatic (patient positioning, air moistening, AD vitamins). Stridor spontaneously vanishes around the 18<sup>th</sup> month of child age, ligament structure of larynx strengthens.

**Complications:** retraction of jugulum and intercostal muscles, cyanosis during crying. Suffocation and phonatory problems are not present.

**Differential diagnostics:** all other congenital defects

### Laryngocele

**Definition:** laryngeal mucosa evagination full of air and mucus. It is localized in meatusriculus laryngis. We differentiate inner and outer one.

**Etiology:** rare congenital defect

**Pathogenesis:** outer one evaginates outwards through membrana thyreochoidea and is palpable on the lateral part of the neck. It looks like a cyst, but it increases during Valsalva's maneuver. The inner one develops as a hernia of meatusriculus laryngis.

**Symptoms:** they are the same in both types: hoarseness, dysphagia, sometimes dyspnea. In case of forced expiration we can see a bulge on the lateral part of the neck.

**Diagnostics:** laryngoscopy, X-ray or CT (we can see air or contrast fluid inside)

**Therapy:** surgical – resection.

**Complications:** breathing and swallowing problems

**Differential diagnostics:** cyst does not change its shape

### **Diaphragma laryngis**

**Definition:** membrane in glottis area, it causes severe dyspnea

**Etiology:** stopped larynx development in the 10<sup>th</sup> embryonic week

**Pathogenesis:** fibrous membrane is localized in frontal 1/3 between the vocal cords. The membrane can be in supra or subglottic area and has a variable thickness.

**Symptoms:** aphonia, breathing problems and stridor. They depend on the size of the membrane.

**Diagnostics:** history, symptoms, laryngoscopy

**Therapy:** tracheostomy is recommended because incisions are healed by scars, which causes strictures of larynx. A definitive solution is made in an older age.

**Complications:** respiratory infection, swelling of airways, respiratory failure

**Differential diagnostics:** other congenital defects of larynx

## **Inflammations of larynx and trachea**

### **Laryngitis acuta**

#### **Laryngitis catarrhalis acuta**

**Definition:** acute inflammation of laryngeal mucosa only

**Etiology:** viral origin

**Pathogenesis:** the disease starts with rhinosinusitis, flu, as a descendent catarrhus of the upper respiratory pathways

**Symptoms:** irritating cough, light dysphonia, light inspiratory stridor, drought and burning in neck

**Diagnostics:** history (viral infection), indirect laryngoscopy (vascular laryngeal mucosa, edematous vocal cords with mucus)

**Therapy:** therapy of basic viral infection, antipyretics, fluids, vitamin C, antihistaminics, spare vocal cords. If bacterial superinfection is present, antibiotics are necessary

**Complications:** commonly night dyspnea with vocal cords spasm, bacterial superinfection and development of acute bacterial laryngitis

### **Laryngitis acuta subglottica**

**Definition:** severe and dangerous form of acute laryngitis which affects submucous fibrous tissue in subglottic space of larynx

**Etiology:** viral (influenza, parainfluenza) with possible bacterial infection

**Pathogenesis:** inflammation with submucous infiltration. There is a sparse submucous tissue in the subglottic space, which can easily tumefy. The developed swelling causes larynx diameter stricture.

**Symptoms:**

- Always present: dyspnoe, inspiratory stridor, dysphonia, barking cough
- Sometimes present: dysphonia, cough

**Diagnostics:** history, laryngoscopy (edematous, red mucosa in form of subglottic stenosis)

**Therapy:**

- first aid: cold wet air, cold-wet compress, patient must sit, lukewarm tea
- medication: corticosteroids (Rectodelt supp.), adrenaline inhalation, antihistaminics, antitustics, expextorantia. Antibiotics in case of bacterial superinfection
- secure airways: intubation or tracheostomy

**Complications:** inflammation progression with daily dyspnea, vocal cords inflammation, laryngotracheobronchitits

### **Epiglottitis acuta**

**Definition:** severe inflammation on submusous tissue, localized behind epiglottis

**Etiology:** Haemophilus influenzae, group B

**Pathogenesis:** Children infectious diseases or larynx injury leads to flegmona. In children, it looks like serous mucosa inflammation with diffuse swelling. It is substantially rarer than laryngitis subglottica. Flegmona is commonly localized on epiglottis and can cause abscess.

**Symptoms:**

- always present: dyspnea, inspiratory stridor, larynx pain, retraction of auxiliary breathing muscles (jugulum, intercostal, epigastrium), cyanosis, paleness, fever, dysphagia, odynophagia, salivation
- sometimes present: dysphonia, cough

**Diagnostics:** history, symptoms, laryngoscopy (edematous red epiglottis)

**Therapy:**

- first aid: lay on guts, koniotomy
- secure airways: intubation, koniotomy or tracheostomy
- medication: antibiotics, antiedematous therapy (corticosteroids), vital functions monitoring

**Complications:** epiglottal abscess. In this case, a yellowish cap can be seen on the lingual part of the epiglottis. Incision and dilatation are necessary. There can be even the unconfined form with a septic state, the inflammation can spread to the mediastinum or cartilage and cause perichondritis.

*'Prevention: **vaccination (obligatory in the Czech Republic)**'*

**Laryngitis oedematosa**

**Definition:** an inflammation of the laryngeal mucosa with serous infiltration of the submucous tissue

**Etiology:** laryngeal swelling can develop during larynx or perilaryngeal inflammation (paratonsillary or parapharyngeal abscess). A non-infectious swelling can develop after an injury, due to burning, a foreign body, by children due to an allergy or gastroesophageal reflux disease (GERD)

**Pathogenesis:** transudate caused by lympho- or venostasis infiltrates laryngeal fibrous tissue in places, where it is very thin (epiglottis, subglottis, aryepiglottic plicae)

**Symptoms:** acute dyspnea, inspiratory stridor, suffocation

**Diagnostics:** history, symptoms, laryngoscopy (pale swelling)

**Therapy:** hospitalization, ATB, corticosteroids, antihistaminics, calcium, intubation or tracheostomy

**Laryngotracheobronchitis pseudomembranacea et crustosa**

**Definition:** an inflammation of the larynx, trachea and bronchi with mucosal swelling and pseudomembranes

**Etiology:** bacterial superinfection (Staphylococci) after viral inflammation (flu, measles)

**Pathogenesis:** airways obstruction is caused by mucosal swelling, exudate (which gets dry and forms crusts) and pseudomembranes (contains fibrin, leucocytes, epithelia, microbes). In case of a severe form, the inflammation spreads from the larynx to the trachea and the bronchi. Total obstruction with atelectasis or valve occlusion with emphysema can develop in the bronchi. Airways obstruction or sepsis can lead to suffocation or even death of the child.

**Symptoms:** the child has breathing problems, is suffocating, inspiratory or expiratory stridor is present. The child retracts epigastrium, jugulum, supraclavicular area, intercostal muscles or possibly the whole chest during inspiration. The child is pale or cyanotic, restless, has a fever and can have dysphonia.

**Diagnostics:** history, laryngoscopy (red, edematous mucosa with thick mucus and sometimes with pseudomembranes and crusts)

**Therapy:** hospitalization is necessary, ATB, corticosteroids, antihistaminics, cardiotonics, calcium, oxygen, moisten air. In case of worsening, intubation or tracheostomy is required. According to the state of the children, bronchoscopy with mucus and crusts removal may be needed.

### **Laryngitis chronica**

**Definition:** a chronic inflammation of the laryngeal mucosa, can be hypertrophic or atrophic. Practically not present in children.

**Etiology:** repeated nasal mucosa, pharynx or paranasal sinuses inflammation, allergy, frequent laryngitis, flegmonous mucosal inflammation, GERD, surgery of larynx, hyperthyreosis, diabetes mellitus, anemia, chronic kidney diseases, hormonal changes, environmental factors, result of burning

**Pathogenesis:** fibrous tissue hyperplasia in laryngeal mucosa, slime glands and lymphatic tissue atrophy

**Symptoms:** hyperplastic mucosa can cause light respiratory or voice problems. The mucus dries on the vocal cords during atrophic laryngitis and causes hoarseness and cough.

**Diagnostics:** history, laryngoscopy

**Therapy:** the cause of chronic laryngitis has to be found out. This cause has to be eliminated, spa therapy and airways moistening is recommended.

**Complications:** this disease is considered as a precancerosis

## Specific laryngeal inflammation

**Etiology:** mycobacterium tuberculosis (TBC), treponema pallidum syphilis, klebsiella ozenae or rhinoscleromatosis

**Pathogenesis:** systemic disease which can affect laryngeal mucosa

### Symptoms:

- TBC has miliary and infiltrative form with nodes and ulcers on mucosa. In chronic infiltrative form, the vocal cords are edematous and red.
- Syphilis - larynx has ulcers, infiltrates and enanthema
- Other specific inflammations are very rare

**Diagnostics:** serology, history, laryngoscopy

**Therapy:** therapy of given disease

**Complications:** depends on the disease

## Tumors of larynx and trachea

### Benign tumors of larynx and trachea

#### Hemangioma

**Pathogenesis:** the tumor can be found on different places, most often it is found in the subglottic area on the side. Size varies, the tumor can spread to the pharynx or cervical spondyls. Hemangioma is more frequent in girls.

**Symptoms:** subglottic hemangioma causes stridor, sometimes dysphonia and dyspnea

**Diagnostics:** history, CT, angiography, laryngoscopy (blue-red formation). Biopsy cannot be performed because of a risk of bleeding.

**Therapy:** embolization, corticosteroids. Haemangiomas spontaneously involute at the age of 2-3 years. Tracheotomy if airways obstruction is present. Radiotherapy is not recommended because of imminent larynx growth disorder and a risk of thyroid gland carcinoma development. Endoscopic cryotherapy can cause a stricture. Surgical ablation via laryngeal fissure is possible, as well as laser ablation.

**Complications:** dysphonia, dyspnoea, dysphagia

#### Polyp

**Definition:** organized haematoma

**Etiology:** smoking, voice overstrain

**Pathogenesis:** polyp develops due to a chronic irritation of mucosa after voice overstrain, it is impaired by smoking or environmental factors. The result is haematoma organization.

**Symptoms:** dysphonia, increased voice fatigue

**Diagnostics:** laryngoscopy (widely attached formation in frontal and middle third of vocal cord, it has a smooth surface and a pale or red colour), history

**Therapy:** voice using practice, microlaryngoscopic ablation

### **Papillomatosis**

**Definition:** it is the most common benign tumor of larynx in children

**Etiology:** human papilloma virus (HPV-6, HPV-11)

**Pathogenesis:** the virus is transmitted due to bad hygiene or from mother to child during the birth. There are about 50 types of virus. HPV causes warts, papillomas in oral cavity and nose or condylomas in anogenital area

**Symptoms:** hoarseness, dysphonia, aphonia, inspiratory stridor, dyspnea, skin papillomas or condylomas in the anogenital area are often present.

**Diagnostics:** history, laryngoscopy (pink or pale formation commonly localized on vocal cords, can be found in supra- or subglottic part of larynx as well). If a child has a persistent dysphonia or repeating laryngitis, laryngoscopy in anaesthesia is indicated.

**Therapy:** microlaryngoscopic or surgical ablation. If the patient receives a conservative treatment (ATB, hormones, vitamins, cytostatics, interferon), recurrence is frequent.

### **Other tumors**

Fibroma, lipoma, myxoma, neurofibroma, ...

**Symptoms:** dysphonia and stridor – depends on the size and the localization of the tumor

**Diagnostics:** histological examination

**Therapy:** microscopic surgery, voice training after ablation is necessary

### **Malignant tumors of larynx and hypopharynx**

**Definition:** most frequent are carcinomas and sarcomas

**Etiology:** smoking (smokers especially with more than 20 cigarettes per day for 20 years, 90% are men), alcoholism. Malignant tumors are exceptional in children.

**Pathogenesis:** Most frequent is a spinocellular carcinoma. TNM classification describes the disease stage and is only for carcinomas:

- T category: the extent of the primary tumor
- N category: the presence of tumor in the regional cervical lymphatic nodes
- M category: the presence of distant metastases

From these categories, we can assess the disease stage by determining the early stages (I, II) and the late stages (III, IV)

**Symptoms:** they depend on size and localization of tumor. Most frequent is hoarseness. Earliest presence of hoarseness is in case of tumor localized on the vocal cords. About 50% of malignant tumors are localized in the glottic area. Because of early hoarseness it can be earlier diagnosed (and cured) and therefore it has a better prognosis. Metastases are rare. A supraglottic carcinoma is present in spirits drinkers and smokers. Tumors of the laryngeal entrance have odynophagia as a first sign. Every patient with hoarseness or swallowing problems longer than 3 weeks should undergo laryngoscopy because those symptoms are often disregarded. In late stage, cough, haemoptysis, dyspnea or suffocation are present.

**Diagnostics:** history, microlaryngoscopy and histological examination. Diagnosis must be histologically confirmed.

**Therapy:** Disease stage and histopathological grading is important for therapy and prognosis. Grading is level of tumor cells. It is described from G1 to G4. Therapy is surgical and oncological (radiotherapy and chemotherapy) or combination of both.

Surgical therapy: laryngectomy

**Prognosis:** early stages of glottic form of carcinoma has a good prognosis. Supraglottic and subglottic forms come usually in later stages so the prognosis is worse (in addition those types have early metastases).

## Injuries of larynx and trachea

### External injuries of larynx

#### Blunt injury

Strike with a blunt weapon on the ventral part of the neck.

- commotion – edema of mucosa

symptoms: dyspnea, cough

Therapy: corticosteroids

- contusion – damage of submucous tissue

symptoms: dyspnea, cough, hematoma

therapy: corticosteroids, securing airways

- compression – fractures of cartilages

symptoms: dyspnea, cough, emphysema, hematoma

therapy: corticosteroids, ATB, securing airways

### **Sharp injury**

Gunshot, stab or cutting

Therapy: surgery, ATB, corticosteroids

### **Inner injuries of larynx**

#### **Burning (acid or alkali) and scalding**

Aspiration of corrosive substances, gases, hot steam

Symptoms: pain during speech and swallowing or even in rest, subcutaneous emphysema, bleeding, dyspnea

Therapy: securing airways, surgery, corticosteroids, ATB

### **Aspiration**

Definition: the aspiration of a foreign body from the oral cavity through the larynx into the trachea and the bronchi. We divide them into acute and chronic.

Etiopathogenesis:

- undeveloped teeth, infection of airways, unrest during eating (usually peanut, vegetable or toys)
- games, insufficient number of upper limbs (pin, nails, ...)

Majority of foreign bodies (60%) are localized in the right bronchus (it is larger and more straight than the left one)

Symptoms:

- dyspnea, irritating cough, cyanosis, suffocation
- minimal symptomatology (during this phase patient visits the doctor!!)
- bronchopneumonia

According to foreign body position, lung ventilation can be afflicted physiologically or partially – a valve closure can develop. In this case, the inhaled air passes into the lung but cannot go out and this results in pulmonary emphysema. In case of total closure, atelectasis develops. If a foreign body stays in the bronchus for a long time, it causes inflammation and granulation tissue formation. There are recurrent suppurating bronchitis, pneumonia, atelectasis or even a pulmonary abscess. These symptoms are more significant and often in organic foreign bodies.

Diagnostics:

- history – needed for bronchoscopy indication
- clinical ENT examination, lung auscultation
- imaging methods: X-ray – can reveal foreign bodies. We can see atelectasis or emphysema in non-contrast bodies
- bronchoscopy

Therapy:

- first aid: Heimlich's maneuver (cannot be used in pregnant women and young children), laryngotomy (foreign bodies located near vocal cords)
- bronchoscopy with foreign body extraction, ATB in case of inflammation
- thoracotomy (if bronchoscopic extraction is unsuccessful)

### **Stenosis after intubation**

A specific group of diseases forms long lasting intubation. Endotracheal or tracheostomic cannula cause tracheomalacia (caused by cannula's balloon pressure on the tracheal wall) with cicatrication and stenosis or even a fistula development. Postintubation granulomas are formed in dorsal part of glottis.

Therapy: balloon dilatation, tracheotomy, tracheoplasty

### **Injury of cricoarytenoid articulation**

Etiology: it is usually caused by injury of cricoarytenoid articulation during intubation. Intubation can cause luxation of this articulation. This articulation can be afflicted in case of stenosis in dorsal commissure as well.

Symptoms: restriction of voice efficiency, persistent hoarseness, dyspnea in case of stenosis, however there can be no symptoms at all.

Diagnostics: during laryngoscopy we can see vocal cords in the medial position, arytenoid protuberance in larynx interior (similar picture as in unilateral affliction of n. Laryngeus recurrens), peroperative examination of arytenoid cartilage mobility, EMG of larynx with normal findings (without signs of denervation or reinnervation).

Therapy: mobilization or reposition of arytenoid cartilage, often unsuccessful because of fibrotization in the vicinity of articulation

Differential diagnostics:

- unilateral paralysis of the vocal cords – EMG with signs of denervation or reinnervation, arytenoid cartilage is normally mobile
- rheumatoid arthritis – in history we miss tracheal intubation. Rheumatologic examination is needed.

## Larynx innervation defects

### Unilateral vocal cord paralysis

**Etiology:** the most frequent cause is iatrogenous damage of n.laryngeus recurrens during thyroid gland surgery. Another possibility is an invasion of n.vagus or n. laryngeus recurrens by tumor (of cranial base, thyroid gland, oesophagus, lungs) or pressure of enlarged lymphatic nodes (lymphomas and metastases of malignant tumors). If previous causes are excluded, unilateral paralysis is described as a idiopathic (a common cause is viral or another inflammatory damage)

**Symptoms:** bilateral paralysis: usually sudden aphonia or dysphonia. Typical is great dyspnea and voice disability. Dysphagia of fluids can be present. If damage of n.vagus is localized before n.laryngeus superior, risk of aspiration is increased because of laryngeal anaesthesia. Dyspnea in unilateral paralysis is rare (it is present only in patients with need of a higher positive endrespiratory pressure – e.g. asthmatics). Patients have a feeling of breathlessness during speech because of insufficient glottis closure.

**Diagnostics:** voice examination and/or voice analysis. Vocal cords immobility is seen during laryngoscopy. Vocal cords are in a paramedial position, arytenoid tuber of afflicted side is sucked into larynx interior. Absence of tumor must be confirmed if a trauma or iatrogenous damage is excluded. Ventral and lateral X-ray of the chest is a must. In case of uncertainty, CR or MRI has to be performed. Possible is electromyography (EMG) of laryngeal muscles (m.cricothyreoideus and m. thyreoarytenoideus) by percutaneous needle. EMG is used for diagnostic and prognostic reasons.

**Therapy:** If the cause is idiopathic or sometimes iatrogenous, paralysis can be transitory and fast spontaneous recovery follows. If the paralysis is long lasting or permanent, therapy depends on patients' demands on voice quality. To make voice more sonant, glottis closing

has to be performed by compensatory hyperabduction of afflicted vocal cord to the good one. Sometimes it happens spontaneously, sometimes voice training is necessary. Surgery is indicated where voice is unsatisfactory even after training and there is no chance to movement recovery (after more than 1 year, or confirmed by EMG). It depends on the age of the patient because atrophy of m.vocalis will develop after several years from the start and glottis insufficiency will worsen and cannot be compensated.

**Differential diagnostics:** an injury of cricothyroid joint must be excluded. Vital information will offer EMG.

## Differential diagnostic of dyspnea

**Definition:** dyspnea is difficult breathing caused by i.a. airways constriction, followed by stridor (murmur developing when air passes through constricted airways)

### Classification:

- Inspiratory stridor: caused by constriction of the larynx and the trachea (to the bifurcation). Dysphonia is often present.
- Expiratory stridor: caused by constriction of the trachea and the bronchi (behind bifurcation). Voice is clear.
- Inspiratory and expiratory stridor: airways obstruction spreads from the larynx to the bronchi or vice versa (laryngotracheobronchitis)
- Pharyngeal stridor: caused by nose or pharynx obstruction (mucus swelling, adenoids, polyps, tonsils hypertrophy)

The type of stridor helps to find approximate localization of the obstruction. Voice volume and intensity can change, e.g. during work. Stridor can develop slowly or appear suddenly. If oxygenation is insufficient, breath gets deeper and slower and auxiliary muscles start working. Sucklings have alar breathing (simultaneous nostrils movement with breath). Cyanosis, exhaustion, suffocation, unconsciousness and arrhythmia appear after some time.

### Differential diagnostic in children:

- Amniotic fluid aspiration
- Asphyctic syndrome (defective intrauterine breathing transformation to postnatal form).
- Congenital defects of airways (choanal atresia, congenital tumors of nasopharynx, laryngeal or paralaryngeal cysts, atresia or stricture of larynx and trachea, lung hypotrophy, etc.), swallow pathways (macroglossia, ductus thyreoglossus cysts, etc.), heart or large veins anomalies, congenital mediastinal tumors, diaphragmatic hernia, congenital defects of central nervous system (hydrocephalus, bulbar paralysis), perinatal damage of CNS (bleeding)

- Aspirated foreign bodies
- Laryngeal inflammation (laryngitis, epiglottitis, laryngeal phlegmona laryngeal abscess, etc.)
- Injury of airways
- Paralysis of laryngeal muscles (central damage, n.vagus branch damage, myopathy)
- Tumors of larynx and lower airways
- Diseases of pharynx and oral cavity (abscess, phlegmona, tumor, OSAS – obstruction sleep apnea syndrome, etc.)

**Therapy:** secure airways, resuscitation, intubation, bronchoscopy, tracheostomy

## Basics of laryngeal and tracheal surgery

### Microsurgery of larynx

**Definition:** removing or treatment of lesser pathology during direct laryngoscopy with the help of operational microscope. Pay attention to save function. Possible is the use of laser, cryotherapy or local chemotherapy.

### Laryngectomy

- Partial laryngectomy horizontal: epiglottectomy
- Partial laryngectomy fronto-lateral: is performed in vertical level if the glottis is afflicted. Partial laryngectomy can be performed by external approach or by endoscope during direct laryngoscopy. Chordectomy is the most frequent vertical partial laryngectomy.
- Total laryngectomy: during this whole larynx is removed (extensive tumor affliction in III. or IV. stage) and tracheostomy is performed. Regional lymphatic nodes have to be always checked. If they are histologically positive, neck dissection has to be performed. By total laryngectomy respiratory function of larynx and voice are disrupted so we must substitute them. Respiratory function is substituted with permanent tracheostomy, voice can be substituted with 3 possibilities: (esophageal voice training, electrolarynx or implantation of voice prosthesis)

### Coniotomy, conipunction

**Definition:** cutting through or thrust through ligamentum conicum (thyreocricoidium)

**Indications:** first aid in apneusis caused by pathology localized cranially from ligamentum conicum

## **Tracheostomy**

### **Definition:**

- Tracheotomy: cutting through the trachea usually from horizontal or possibly vertical incision. We must spare the first and second tracheal ring because of frequent development of subglottic stricture
- Tracheostomy: trachea opening in the neck via tracheostomic cannula
- Punctured tracheostomy: this is usually performed by an anaesthesiologist under the control of the flexible optic. It is contraindicated in small children due to the small size, mobility and flexibility of the trachea.

### **Classification:**

- upper tracheotomy: above the thyroid isthmus
- middle tracheostomy: after cutting through the thyroid isthmus
- lower tracheostomy: under the thyroid isthmus

### **Indications:**

- long lasting intubation
- airways dead space reduction
- airways obstruction
- total laryngectomy