ANATOMY OF THE RESPIRATORY SYSTEM & MEDIASTINUM

14.11.2014

Kaan Yücel
M.D., Ph.D.
http://mdp120.org
yeditepeanatomy@yahoo.com

A TOTAL 14 FIGURES & 1 LAB VIDEO INSERTED IN THE TEXT
1. NOSE & NASAL CAVITIES

Nose is divisible into 2 parts. One part is external nose. The other one is nasal cavity.

1.1. EXTERNAL NOSE

The external nose extends the nasal cavities onto the front of the face. It is pyramidal in shape. Its apex is anterior in position. The nares are oval apertures on the inferior aspect of the external nose. They are the anterior openings of the nasal cavities. The nares are continuously open. They can be widened further by the action of the related muscles of facial expression. External nose has bony and cartilaginous parts.

Bones contributing to the structure of the external nose:
- Nasal bones
- Frontal process of maxilla
- Nasal part of frontal bone

Cartilages contributing to the structure of the external nose:
1. Major & minor alar cartilages (paired)
2. Septal cartilage (single)

The septal cartilage [Cartilago septi nasi] is a T-shaped cartilage formed by two plates. The vertical plate is the cartilaginous part of septum nasi. The greater alar cartilages form the skeleton of the alae nasi. There are two bones in the nasal septum. They are vomer and perpendicular plate of ethmoid bone. The nasal septum forms the medial wall of the nasal cavities.

1.2. NASAL CAVITIES

The two nasal cavities are the uppermost parts of the respiratory tract. They contain the olfactory receptors. The nasal cavities are separated from each other by the nasal septum in the midline. They are separated from the oral cavity below by the hard palate. They are separated from the cranial cavity above by parts of the frontal, ethmoid, and sphenoid bones. Lateral to the nasal cavities are the orbits. Posteriorly, each nasal cavity communicates with the nasopharynx through two openings called choana [e]. Each nasal cavity consists of 3 general regions. The first region is the nasal vestibule. It is a small dilated space internal to the naris. It is lined by skin and contains hair follicles. The second region is the respiratory region. It is the largest part of the nasal cavity. It has a rich neurovascular supply. It is lined by respiratory epithelium composed mainly of ciliated and mucous cells. The third region is the olfactory region. It is small. It is at the apex of each nasal cavity. It is lined by olfactory epithelium. It contains the olfactory receptors. The lateral wall of the nasal cavity is characterized by three curved shelves of bone. These projections are called conchae. They are one above the other. They are called as inferior nasal concha (a separate bone) and middle and superior nasal conchae (parts of the ethmoid bone). They project medially and inferiorly across the nasal cavity.

- Inferior nasal meatus is between the inferior concha and the nasal floor.
- Middle nasal meatus is between the inferior and middle concha.
- Superior nasal meatus is between the middle and superior concha.
- Spheno-ethmoidal recess is between the superior concha and the sphenoid bone.

These conchae increase the surface area of contact between tissues of the lateral wall and the respired air. The openings of the paranasal sinuses are extensions of the nasal cavity. They erode into the surrounding bones during childhood and early adulthood. They are located on the lateral wall and roof of the nasal cavities.

1.3. FUNCTIONS OF THE NOSE AND THE NASAL CAVITIES

1) Olfaction (sense of smell)
2) Respiration
3) Filtration of the dust in the inspired air
4) Humidification and warming of the inspired air (cooling the internal carotid artery for brain)
5) Reception of the secretions from the paranasal sinuses and nasolacrimal ducts
2. PARANASAL SINUSES

Paranasal sinuses are air filled spaces lying within the bones around the nasal cavity. The paranasal sinuses develop as outgrowths from the nasal cavities and erode into the surrounding bones. All are:

- lined by respiratory mucosa;
- open into the nasal cavities; and
- innervated by branches of the trigeminal nerve [V].

Sinuses are named according to the bones they are located in:

- Frontal sinuses
- Ethmoid sinuses
- Sphenoid sinuses
- Maxillary sinuses (largest)

The air respired in travels from the nasal cavities into the nasopharynx (nasal part of the pharynx) then into the laryngeal cavity. The nasopharynx will be covered in the digestive system under “pharynx”.

3. LARYNX

Larynx is the organ of phonation (vocalization). It is formed of cartilage, muscles and connective tissue. The cavity of the larynx is continuous below with the trachea. Above it opens into the pharynx immediately posterior and slightly inferior to the tongue. The larynx lies between the C3-C6 vertebrae.

3.1. CARTILAGES OF THE LARYNX

Skeleton of larynx is formed of 3 unpaired and 3 paired cartilages. The unpaired cartilages are: thyroid cartilage (biggest), cricoid cartilage and epiglottic cartilage. The paired cartilages are: arytenoid, corniculate and cuneiform cartilages.

Thyroid cartilage: is the largest cartilage of the larynx. It is formed of two laminae which fuse anteriorly at the thyroid angle to form laryngeal prominence (Adam’s apple). The angle between the two laminae is more acute in men (90°) than in women (120°) so the laryngeal prominence is more apparent in men than women.

Cricoid cartilage: is a ring shaped cartilage.

Arytenoid cartilages: are pyramidal in shape. An arytenoid cartilage has three processes:

- Apex (superior),
- Vocal process (anterior), vocal ligament attaches here
- Muscular process (lateral)

The anterolateral surface has two depressions, separated by a ridge, for muscle (vocalis) and ligament (vestibular ligament) attachment. The anterior angle of the base is elongated into a vocal process to which the vocal ligament is attached.

Epiglottic cartilage (Epiglottis): is a leaf-shaped cartilage attached by its stem to the posterior aspect of the thyroid cartilage at the angle. It projects posterosuperiorly over the thyroid cartilage.

Corniculate and cuneiform cartilages: The corniculate cartilages are two small conical cartilages. Their bases articulate with the apices of the arytenoid cartilages. The cuneiform cartilages are small cartilages lie anterior to the corniculate cartilages and are suspended in the part of the fibro-elastic membrane of the larynx.

3.2. LIGAMENTS OF THE LARYNX

3.2.1. Extrinsic ligaments

Thyrohyoid membrane, hyo-epiglottic ligament and cricotracheal ligament.

3.2.2. Intrinsic ligaments- Fibroelastic membrane of the larynx

The fibroelastic membrane of the larynx lies under the mucosa of the larynx. The fibro-elastic membrane of the larynx links together the laryngeal cartilages and completes the architectural framework of the laryngeal cavity. The fibroelastic membrane of the larynx has thickenings at certain regions and forms some of the ligaments between the cartilages.

The fibroelastic membrane of the larynx is composed of two parts-a lower conus elasticus and an upper quadrangular membrane.
**Conus elesticus (cricothyroid ligament, cricovocal membrane, cricothyroid membrane):** Its free upper margin thickens to form the vocal ligament. It is covered by mucosa to form the vocal fold. The opening between the two vocal folds is rima glottis. Each vocal ligament converges anteriorly and attaches to the anterior part of the inner surface of the thyroid cartilage (thyroid angle). Posteriorly they individually attach to the vocal processes of the arytenoid cartilages. Rima glottis widens during inspiration. The two vocal folds are approximated during phonation. Various changes of the vocal folds determine the color, pitch and the tones of sound. Pitch increases with tensing, decreases by relaxation. Intensity of expiration determines the loudness of sound.

### 3.4. LARYNGEAL CAVITY

The cavity of the larynx is tubular. Its architectural support is provided by the fibro-elastic membrane of the larynx and by the laryngeal cartilages to which it is attached. The superior aperture of the cavity (laryngeal inlet) opens into the anterior aspect of the pharynx just below and posterior to the tongue. It is bounded by the upper border of epiglottis, aryepiglottic folds and interarytenoid notch.

The inferior opening of the laryngeal cavity is continuous with the lumen of the trachea, is oblique and points posterosuperiorly into the pharynx. In addition, the inferior opening is continuously open, whereas the laryngeal inlet can be closed by downward movement of the epiglottis.

**Division into three major regions**

Two pairs of mucosal folds, the vestibular and vocal folds, which project medially from the lateral walls of the laryngeal cavity, constrict it and divide it into three major regions: the vestibule, a middle chamber, and the infraglottic cavity.

The vestibule is the upper chamber of the laryngeal cavity between the laryngeal inlet and the vestibular folds, which enclose the vestibular ligaments and associated soft tissues; The middle part of the laryngeal cavity is very thin and between the vestibular folds above and the vocal folds below. The infraglottic space is the most inferior chamber of the laryngeal cavity and is between the vocal folds (which enclose the vocal ligaments and related soft tissues) and the inferior opening of the larynx.

### 3.5. FUNCTIONAL ANATOMY OF THE LARYNX

**Respiration:** During quiet respiration, the laryngeal inlet, vestibule, rima vestibuli, and rima glottidis are open. The arytenoid cartilages are abducted and the rima glottidis is triangular shaped. During forced inspiration, the arytenoid cartilages are rotated laterally, mainly by the action of the posterior crico-arytenoid muscles. As a result, the vocal folds are abducted, and the rima glottidis widens into a rhomboid shape, which effectively increases the diameter of the laryngeal airway.

**Phonation:** When phonating, the arytenoid cartilages and vocal folds are adducted and air is forced through the closed rima glottidis. This action causes the vocal folds to vibrate against each other and produce sounds, which can then be modified by the upper parts of the airway and oral cavity. Tension in the vocal folds can be adjusted by the vocalis and cricothyroid muscles.

**Effort closure:** Effort closure of the larynx occurs when air is retained in the thoracic cavity to stabilize the trunk, for example during heavy lifting, or as part of the mechanism for increasing intra-abdominal pressure. During effort closure, the rima glottidis is completely closed, as is the rima vestibuli and lower parts of the vestibule. The result is to completely and forcefully shut the airway.

**Swallowing:** During swallowing, the rima glottidis, the rima vestibuli, and vestibule are closed and the laryngeal inlet is narrowed. In addition, the larynx moves up and forward. This action causes the epiglottis to swing downward toward the arytenoid cartilages and to effectively narrow or close the laryngeal inlet. The up and forward movement of the larynx also opens the esophagus which is attached to the posterior aspect of the lamina of cricoid cartilage. All these actions together prevent solids and liquids from entry into the airway.
4. TRACHEA

The trachea extends from the inferior end of larynx to the level of T5-T6 vertebra. It terminates by dividing into right and left main bronchi at the sternal angle. Right main bronchus is wider, shorter, runs more vertically. The main bronchi give branches inside the lungs that form the bronchial tree. Trachea is formed of tracheal rings which are incomplete posteriorly.

5. PLEURA

Each pulmonary cavity (right and left) is lined by a pleural membrane (pleura) that also reflects onto and covers the external surface of the lungs occupying the cavities. Each lung is invested by and enclosed in a serous pleural sac that consists of two continuous membranes: the visceral pleura, which invests all surfaces of the lungs forming their outer surface, and the parietal pleura, which lines the pulmonary cavities. The parietal pleura also lines the inner surface of the thorax. The pleural cavity—the potential space between the layers of pleura—contains a capillary layer of serous pleural fluid, which lubricates the pleural surfaces and allows the layers of pleura to slide smoothly over each other during respiration.

6. LUNGS

The two lungs are organs of respiration. They lie on either side of the mediastinum. They are surrounded by the right and left pleural cavities. Air enters and leaves the lungs via main bronchi. These bronchi are branches of the trachea. Their main function is to oxygenate the blood by bringing the inspired air into close relation with the venous blood in the pulmonary capillaries. The pulmonary arteries deliver deoxygenated blood to the lungs from the right ventricle of the heart. Oxygenated blood returns to the left atrium via the pulmonary veins.

The most of the liver is on the right side. So the right lung is 2.5 cm. shorter than the left lung. The right lung is wider with a much more total capacity and weight than those of the left lung.

Each lung bears the following features:
- Apex (upper pole)
- Three surfaces (costal, mediastinal and diaphragmatic).
- Root of the lung is formed by the structures entering and leaving the lung through its hilum.
- There are two lobes (superior lobe & inferior lobe) in the left lung separated by the oblique fissure.
- There are three lobes (superior lobe, middle lobe, inferior lobe) in the right lung. They are separated by horizontal and oblique fissures. The middle lobe is between these two fissures.

Lobes and fissures of the lungs

TRACHEOBRONCHIAL TREE

Beginning at the larynx, the walls of the airway are supported by horseshoe- or C-shaped rings of hyaline cartilage. The sublaryngeal airway constitutes the tracheobronchial tree. The trachea, located within the superior mediastinum, constitutes the trunk of the tree. It bifurcates at the level of the transverse thoracic plane (or sternal angle) into main bronchi, one to each lung, passing inferolaterally to enter the lungs at the hila (singular = hilum). Within the lungs, the bronchi branch in a constant fashion to form the branches of the tracheobronchial tree. Each main (primary) bronchus divides into secondary lobar bronchi, two on the left and three on the right, each of which supplies a lobe of the lung. Each lobar bronchus divides into several tertiary segmental bronchi that supply the bronchopulmonary segments. The bronchopulmonary segments are:
- The largest subdivisions of a lobe.
- Pyramidal-shaped segments of the lung, with their apices facing the root of the lung.
- Supplied independently by a segmental bronchus and a tertiary branch of the pulmonary artery.
- Named according to the segmental bronchi supplying them.
- There are 10 bronchopulmonary segments in each lung. Some of them are fused in the left lung.
- Surgically resectable.
Beyond the tertiary segmental bronchi, there are generations of branching conducting bronchioles that eventually end as terminal bronchioles, the smallest conducting bronchioles. Bronchioles lack cartilage in their walls. Each terminal bronchiole gives rise to several generations of respiratory bronchioles, characterized by scattered, thin-walled outpocketings (alveoli) that extend from their lumens. The pulmonary alveolus is the basic structural unit of gas exchange in the lung.

**Branching of the tracheobronchial tree:**

1. Trachea
2. Principal bronchus
3. Lobar bronchi (secondary bronchi)
4. Segmental bronchi (tertiary bronchi)
5. Conducting bronchiole
6. Terminal bronchiole
7. Respiratory bronchiole
8. Alveolar duct
9. Alveolar sac
10. Alveolus

The mediastinal pleura reflects off the mediastinum as a tubular, sleeve-like covering for structures (i.e., airway, vessels, nerves, lymphatics) that pass between the lung and mediastinum. This sleeve-like covering, and the structures it contains, forms the **root of the lung**. The root joins the medial surface of the lung at an area referred to as the **hilum of lung**. Here, the mediastinal pleura is continuous with the visceral pleura.

**VASCULATURE OF THE PLEURA AND THE LUNGS**

Each lung has a pulmonary artery (carries venous blood) and two pulmonary veins (carries arterial blood). Each lobe and segment has its own artery. Branching of the arteries follow the bronchial tree and terminate as capillaries around the alveoli. Intersegmental part of the pulmonary veins run within the septa and drain the segments. Pulmonary veins also drain the visceral pleura. Veins of the parietal pleura drain into the systemic veins mainly through the intercostal veins.

**Bronchial arteries:** Left bronchial arteries (from thoracic aorta) are paired and the right bronchial artery (usually arises from 3rd posterior intercostal artery) is one single artery. Parietal pleura is supplied by arteries of the thoracic wall.

**Bronchial veins:** Right bronchial vein drains into the azygos vein, whereas left bronchial vein drains into the accessory hemiazygos vein.

**NERVES OF THE LUNGS AND PLEURA**

Lungs are innervated by pulmonary plexuses, which contain both sympathetic and parasympathetic nerves. The vagus nerve supplies parasympathetic innervation (bronchoconstrictor, vasodilator to the lung vessels, secretomotor to the glands). The sympathetic innervation comes from the sympathetic trunk (bronchodilator, vasoconstrictor to the lung vessels, inhibitor to the glands). Innervation of the parietal pleura is by intercostal and phrenic nerves.

**7. MEDIASTINUM (Interpleuraul space)**

The thoracic cavity is divided into 3 major spaces. One space is the central compartment or mediastinum. The mediastinum has the organs of in the chest except lungs. On each side of the mediastinum there are right and left pulmonary cavities. The lungs are in these cavities.

The mediastinum means middle septum, midway in Latin. It is occupied by the mass of tissue between the two pulmonary cavities. It is the central compartment of the thoracic cavity. It is covered on each side by mediastinal pleura and contains all the thoracic viscera and structures except the lungs. Mediastinum extends from superior thoracic aperture superiorly to the diaphragm inferiorly and from sternum and costal cartilages anteriorly to to the bodies of the thoracic vertebrae posteriorly.

The mediastinum is a dynamic area. The looseness of the connective tissue and the elasticity of the lungs and parietal pleura on each side of the mediastinum are good for changes in the movement and size.
These features enable it to accommodate movement as well as volume and pressure changes in the thoracic cavity. An example is change in size resulting from movements of the diaphragm, thoracic wall, and tracheobronchial tree during respiration. The change in size can be due to contraction (beating) of the heart. It can also be a result of pulsations of the great arteries. The change in size can be due to passage of ingested substances through the esophagus.

*The mediastinum is divided into superior and inferior parts for purposes of description.*

**Superior mediastinum** is above the sternal angle. The sternal angle refers to the level between the 4th and 5th thoracic vertebrae posteriorly. The superior mediastinum has some important structures. They are trachea, esophagus, thymus, vagus nerve, phrenic nerve and great vessels such as arch of aorta, brachiocephalic vein.

Inferior to the sternal angle is the **inferior mediastinum**. The inferior mediastinum is divided into 3 parts.

The heart is in the middle. The **anterior mediastinum** is anterior to pericardium. The major structure here is part of the thymus. The **middle mediastinum** has pericardium, heart and beginnings of the great vessels emerging from the heart. The **posterior mediastinum** has some important structures. Some of them are: thoracic aorta, esophagus. The posterior mediastinum is posterior to the pericardium and diaphragm.

Some structures, such as the esophagus, pass vertically through the mediastinum. They lie in more than one mediastinal compartment. The thoracic duct which drains ¾ of the lymph in the body is in the superior mediastinum as well as in the posterior mediastinum just like esophagus.