

Anatomy of the Larynx

Joints of the larynx:

We have two important joints:

1. **Cricothyroid joint;** between the cricoid cartilage and the inferior horn of the thyroid & it's a synovial joint.

The importance of this joint is that it allows movement of the thyroid cartilage forwards and downwards along with rotatory movement; let's imagine the thyroid over the cricoid moving forwards, downwards and rotating, this will affect the length of the true vocal cords leading to either lengthening or shortening of the true vocal cords, and this is mainly used in the process of tension i.e. high pitch of voice.

2. **Cricoaarytenoid Joint;** between cricoid and arytenoid (we said that there are two facets on the upper border of cricoid and the arytenoid is the motile one over them), also here, it's a synovial joint.

The movement of the arytenoid is rotatory; either internally or externally so it affects the true vocal cords causing either adduction or abduction

The muscles that move the joint are the posterior and the lateral cricoarytenoid muscles.

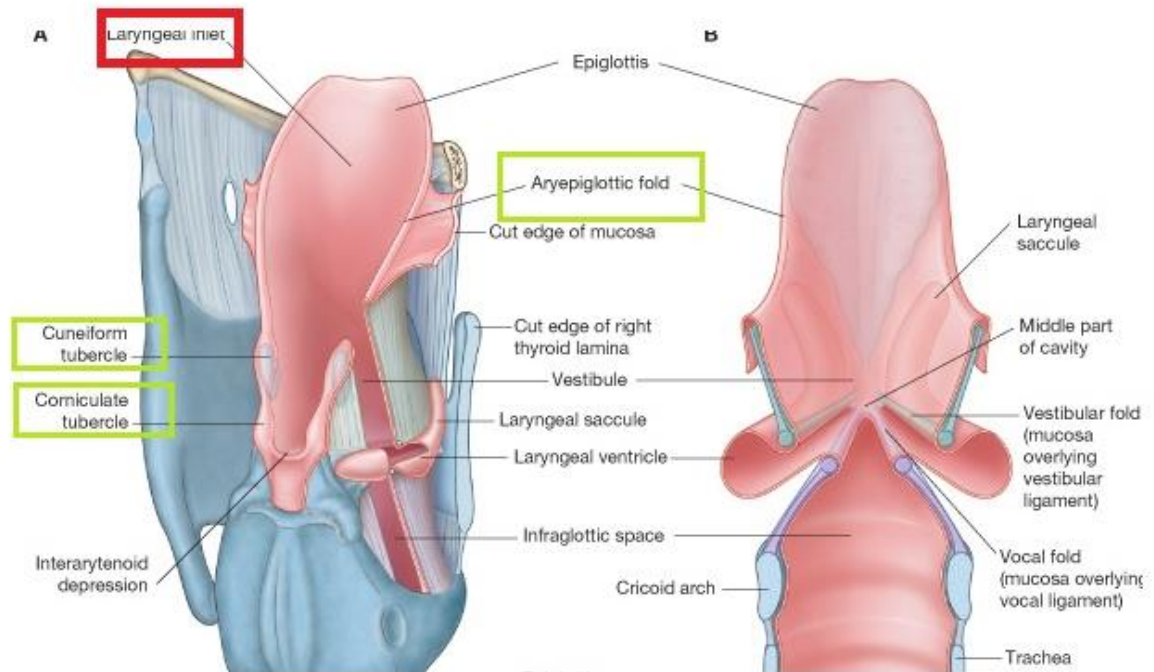
Cavity of the larynx:

Larynx from the inside is divided into 3 parts:

1. **Vestibule;** starts from the inlet and ends at the false vocal cords. And the importance is for the inlet
2. **Middle compartment (also called glottic part);** between the false and the true vocal cords
3. **Infraglottic part;** below the true vocal cords and extends to the trachea

So the cavity of the larynx starts from the laryngeal inlet and ends with the trachea and is divided into 3 parts; vestibule, middle compartment and infraglottic parts.

Now let's take a look at the inlet of the larynx:



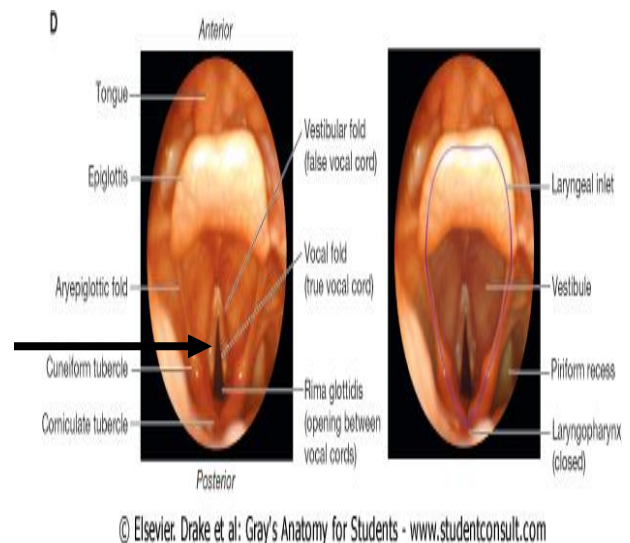
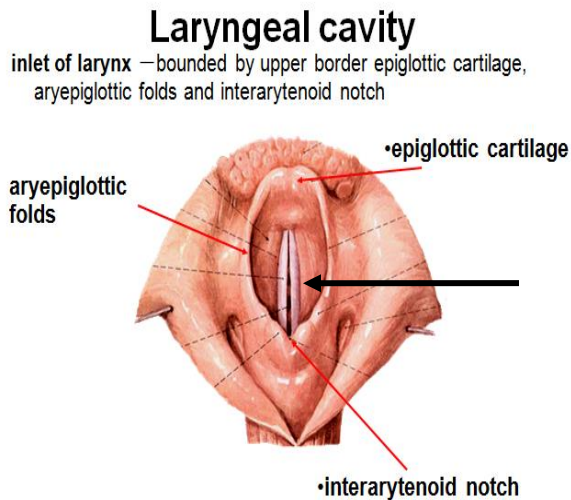
First thing we can see is the root of the tongue which is connected to the epiglottis by the glossoepiglottic folds (median and two lateral glossoepiglottic folds).

Another fold we can see is the aryepiglottic fold, along with the arytenoid, cuneiform and corniculate tubercles which are small cartilages that are present with the fold.

Borders of the inlet of the larynx:

- Above and anterior: free edge of the epiglottis
- On both sides (laterally): Aryepiglottic folds
- Posteriorly: Interarytenoidus (also called; transverse arytenoid) muscle between the two arytenoids and is also covered by a fold of mucosa.

The picture below represents the inlet of the larynx from above:



The white lines (with the arrow pointing at them) are the true vocal cords, and the reason they are white is because they are avascular (no blood vessels).

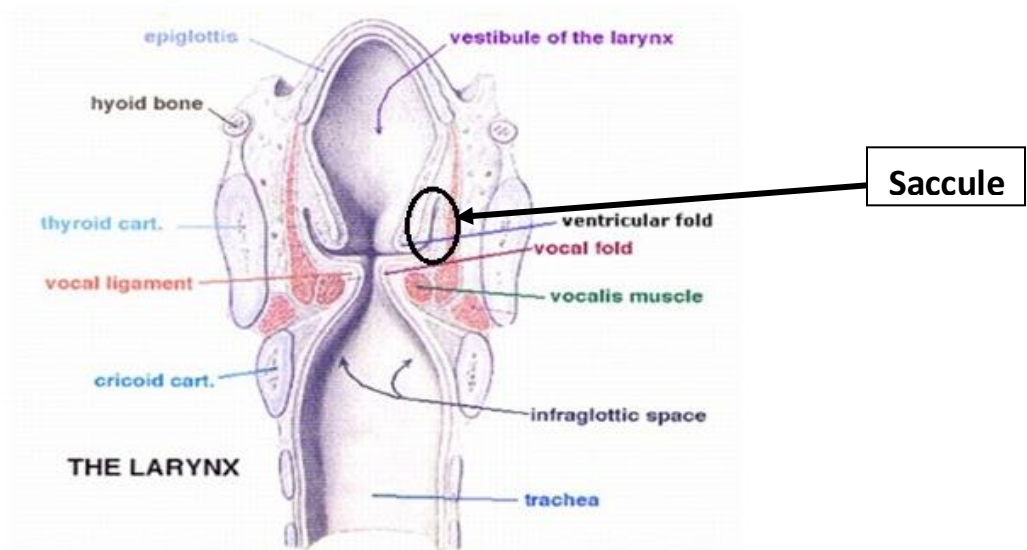
Now the anesthesiologist always keeps this picture in mind because any patient who enters the hospital to do a surgery is given anesthesia IV then the anesthesiologist has to enter an endotracheal tube from the oral cavity towards the oropharynx then the inlet of the larynx and the tube has to be entered between the true vocal cords until it reaches the trachea i.e. the infraglottic part of the larynx, and this is done because; due to any reason adduction of the true vocal cords may occur leading to suffocation, so to guarantee that the operation goes on smoothly an endotracheal tube must be inserted. Even while doing gastroscopy this image is seen while inserting the gastroscope, the only difference is that when they see it they go posteriorly towards the esophagus to reach the stomach, instead of going in between the vocal cords towards the larynx.

Now as we said the aryepiglottic folds form the lateral borders of the inlet of the larynx, and as we said that the cuneiform and corniculate are small cartilages, the corniculate communicates/ articulates with the apex of the arytenoid and is located at the end of the fold, whereas the cuneiform lies above the corniculate.

Inferior opening of the larynx:

Leads to the trachea and is infraglottic, and the importance of the infraglottic part is that the compression of the column of air occurs in it by adduction of the true vocal cords and this is important in the production of voice due to vibration of the true vocal cords

Middle compartment of the larynx:



It contains the ventricle which leads to a saccule. So the ventricle is a space between the false and the true vocal cords in the middle compartment, and it leads to the saccule which is a pouch located upwards.

The importance of the saccule lies in its contents; seromucous glands in the submucosa of the vestibular fold, and when it starts secreting, the secretion is directed towards the true vocal cords lubricating them. So, in other words, these glands are located deep to the false vocal cords but act on the true vocal cords lubricating them.

True vocal cords:

Midsagittal section shows us the true and false vocal cords and the ventricle in between.

Note that the false vocal cords are above the true vocal cords.

Properties of the true vocal cord:

1. It is a **vocal ligament**; which resembles the upper free edge of the conus-elasticus or cricothyroid membrane, attached to the vocal process of arytenoid on one side till the angle of thyroid on the other.
2. This ligament is covered by mucosa, so the **mucous membrane**/ lining epithelium from the inside is of the stratified squamous non-keratinized type, meanwhile above and below it is of the pseudostratified ciliated columnar type (respiratory). And the reason the true vocal cords' epithelium is stratified squamous is that it gets injured and needs mitosis and regeneration.
3. **Vocalis muscle** which is a striated muscle and it affects the length of the vocal cord, **it is** the thyroarytenoid muscle which lengthens the vocal cords (functions in an opposite manner of the cricothyroid muscle which shortens and causes increase in the tension of the vocal cords)
4. **No submucosa**; no accumulation of fluids and edema, because if edema occurred it will cause adduction of the vocal cords and suffocation
5. **No blood vessels**; white in color, but each cell receives blood supply & nutrients by diffusion.
6. It extends from the vocal process of the arytenoid to the angle of the thyroid.
7. Responsible for the **pitch of the voice**, high pitch in females and low pitch in males due to longer vocal cords in males.

Vestibular folds: (false vocal cords)

1. Consist of a fold and a ligament formed by the free lower edge of the quadrangular membrane.
2. Red in color because it has blood vessels
3. Pseudostratified ciliated columnar epithelium
4. Has no action in voice formation (doesn't vibrate)
5. Space between the two folds of the false vocal cords (**Rima vestibuli**) is wider than that space between the true vocal cords (**Rima glottidis**)

* Rima glottidis is the narrowest region between the folds & is the important one in adduction and abduction while rima vestibuli is not as important.

*(Rima means space, glottidis refers to the glottic compartment)

Muscles of the larynx

Are of two types:

a. Extrinsic.

b. Intrinsic: (more important)

Subdivided into 3 groups:

1. Act on the inlet of the larynx (opened or closed).
2. Act on the length of the true vocal cords (tense or relaxed).
3. Act on the vocal cords adducting or abducting them.

* All of the intrinsic muscles are supplied by the recurrent laryngeal nerve which is a branch of the vagus except for the Cricothyroid muscle which is supplied by the external laryngeal nerve which is also a branch of the vagus.

* Cricothyroid muscle is different in its location, action and nerve supply.

Intrinsic Muscles:

- ***Cricothyroid Muscle:***

- Consists of 2 parts; straight and oblique
- Originates from the cricoid and inserts in the thyroid cartilage especially at the lower border and oblique line and inferior horn of it (as the name implies).
- Nerve supply is from the external laryngeal which is a branch of the superior laryngeal which is a branch of the vagus.
(Superior laryngeal nerve gives external laryngeal nerve and internal laryngeal nerve which –the internal- penetrates the thyrohyoid membrane and reaches the mucosa above the true vocal cords, so it's sensory for that area/ sensory above the true vocal cords)
- Action of this muscle is the tension of the true vocal cords meaning that it is responsible for the high pitch of voice.
- Injuries of the external laryngeal nerve are very common since it accompanies the superior thyroid artery, so in cases of thyroidectomy, especially in the presence of a tumor (tumor deforms the anatomy of the thyroid, so the surgeon won't be able to recognize the arteries and nerves), ligation of the superior thyroid artery may mistakenly cause cut of the external laryngeal nerve, and if it was on both sides, the action of cricothyroid is completely lost and hoarseness or weakness of voice occurs.

- **Posterior and lateral cricoarytenoid muscles**
 - From cricoid cartilage to the muscular process of the arytenoid (as the name implies).
 - Innervated by the recurrent laryngeal nerve.
 - Posterior: **abduction** of the true vocal cords; when it contracts it pulls the muscular process outwards and backwards.
 - Lateral -originating from the lateral side of cricoid- : **adduction** of the true vocal cords; when it contracts it pulls the muscular process anterior and internally.
 - So the posterior & lateral cricoarytenoids have opposite functions.
- **Transverse arytenoid muscle**
 - Extends between the two arytenoids transversely.
 - Closes the posterior part of Rima Glottidis because it is positioned posteriorly, so it moves the arytenoids (not the vocal cords) close to each other, this movement is partial and not complete.
 - Innervated by the recurrent laryngeal nerve.
- **Oblique arytenoid muscle**
 - Extends from the base (back/muscular process) of one arytenoid to the apex of the other one obliquely.
 - It causes narrowing of the inlet of the larynx by pulling the posterior part of the inlet (brings the aryepiglottic folds together)
 - Innervated by the recurrent laryngeal nerve.
- **Thyroarytenoid muscle (Vocalis)**
 - As we already mentioned it acts in an opposite manner to the Cricothyroid muscle, since it relaxes (elongates) the vocal cords.
 - Innervated by the recurrent laryngeal nerve
- **Aryepiglottic(us) muscle**
 - Forms a fold.
 - Innervated by the recurrent laryngeal nerve.
 - Widens the inlet by pulling the aryepiglottic folds apart. (Even though in some books it's said that it assists in the closure of the inlet).

What we're interested in while closure of the inlet of the larynx is the movement of the epiglottis downwards and movement of the larynx upwards.

Extrinsic Muscles:

These muscles move the larynx; suprahyoid and infrahyoid.

- ***Suprahyoid muscles:***

- These are elevators of the larynx, they pull it upwards.
- They are:

1. Stylohyoid
2. Myelohyoid
3. Geniohyoid
4. Digastric

- ***Infrahyoid muscles:***

- These are depressors of the larynx, they pull it downwards.
- They are:

1. Sternothyroid
2. Sternohyoid
3. Omothyroid

Functions of the larynx

1. Respiration :

- During respiration, Rima Glottidis must be opened (Space **is present** between the two true vocal cords)
- Respiration occurs along with the opening of the inlet of the larynx

2. Phonation (articulation):

- Building of compressed air column between the true vocal cords then we'll have vibration.
- This air column is subjected to partitioning and it comes out in the form of waves through the walls of the larynx, pharynx, nose and oral cavity & with the contraction of the muscles, articulation occurs.

3. Effort closure:

- Complete adduction of the true and false vocal cords in case of efforts.
- Example; lifting of heavy objects, while lifting we can see that there's no breathing and complete adduction of both vocal cords because the compressed air column gives support to the muscles to lift heavy objects, and once they are put down we get deep inspiration which is an evidence that we had complete adduction.

4. Swallowing (deglutition):

- We have complete closure of the inlet of the larynx during it, and it's not allowed for any food or water particle to enter the larynx.
- In case anything entered the larynx we start coughing to get it out.

- The closure occurs by the movement of the epiglottis backwards and downwards and the larynx upwards.

Blood supply of the larynx

- Larynx is supplied by two arteries:
 1. **Superior laryngeal artery** which is a branch of the superior thyroid artery which is a branch of the external carotid artery.
It pierces the thyrohyoid membrane along with the internal laryngeal nerve; it doesn't get injured during surgeries because the surgeons work away from it, but the superior thyroid artery and the external laryngeal nerve (that supplies the cricothyroid muscle) are at high risk of being injured during surgeries.
 2. **Inferior laryngeal artery** which is a branch of the inferior thyroid artery which is a branch of the thyrocervical trunk of subclavian. Recurrent laryngeal nerve is related to both inferior thyroid and inferior laryngeal arteries, that's why we have common injury to the recurrent laryngeal nerve during thyroidectomy – during ligation of the inferior thyroid artery or inferior laryngeal artery.

Venous drainage of the larynx

- **Superior laryngeal vein** which meets up with the superior thyroid vein which ends in the internal jugular vein.
- **Inferior laryngeal vein** which meets up with the inferior thyroid vein which ends in the left brachiocephalic vein (left is longer and that's why it drains into it).

Lymphatic drainage of the larynx

1. *Above true vocal cords*; along with the superior laryngeal vessels and drain into the deep cervical lymph nodes.
2. *Below true vocal cords*; along with the inferior thyroid vessels and drain into the paratracheal lymph nodes.

Nerve supply of the larynx

We have motor, sensory and parasympathetic innervations for the larynx.

Sensory:

- *Internal laryngeal nerve*; pierces the thyrohyoid membrane to innervate the mucosa above the true vocal cords.
- *Recurrent laryngeal nerve*; innervates the mucosa below the true vocal cords.

Motor:

- All muscles of the larynx are innervated by the recurrent laryngeal nerve except for the cricothyroid muscle which is innervated by the external laryngeal nerve.
- All are branches of the vagus.
- **Superior laryngeal nerve:**
 - Divided into internal laryngeal (sensory to the mucosa above the true vocal cords) and external laryngeal (motor to the cricothyroid muscle) nerves.
- **Recurrent laryngeal nerve:**
 - Sensory to the mucosa below the true vocal cords and motor to all the muscles except the cricothyroid muscle.
 - Origin on the right side differs than that of the left side.
 - *On the right side*; at the root of the neck below the subclavian vessels and ascends between trachea and esophagus.
 - *On the left side*; in the chest below the arch of the aorta then it ascends between the trachea and esophagus.
 - In the end, they both reach the larynx –in the neck- from behind between the larynx and the pharynx.

Relations of the larynx

- **On the lateral side:**
 1. *Carotid Sheath*; which contains the common carotid artery which continues as the internal carotid artery, the vagus nerve and the internal jugular vein.
- **Anteriorly:**
 1. Skin and fascia.
 2. Infrahyoid muscles.
- **Posteriorly:**
 1. Pharynx above & esophagus below.
 2. Recurrent laryngeal nerve between the larynx & the pharynx.

Clinical notes:

During thyroidectomy, external laryngeal and recurrent laryngeal nerves can be injured, because their paths are along the paths of the superior and inferior thyroid arteries respectively.

The recurrent laryngeal nerve is more prone to injury; since it's in between the branches of the inferior thyroid artery (don't get that the inferior laryngeal artery is one of these branches)... so it's very easy to be mistakenly cut.

External laryngeal nerve:

If the sectioning was bilateral we will get weakness/hoarseness of the voice, very common in tumors.

Recurrent laryngeal nerve:

We have 4 types of injuries to the nerve;

1. Unilateral or bilateral section
2. Complete cut or partial (partial means that the superficial fibers get injured by manipulation, using gauze to dry blood may affect the superficial fibers of the nerve which innervate the abductor muscles , so by their injury, there'll be adduction of the vocal cords).

Partial cuts are more dangerous than the complete, because complete cut of the nerve keeps the vocal cords in place/ middle – neither abducted nor adducted- but when partial cut of the nerve occurs, abduction is lost so adduction takes over affecting the respiration.

- Most dangerous injury is that caused by partial bilateral cut of the recurrent laryngeal nerve.
- What do we consider in cases of injury to the recurrent laryngeal nerve:
 - First thing we look at is the respiration whether the airways are still open or not, in other words if the vocal cords were adducted or not, because it may cause suffocation in case of adduction.
So, we check the respiration whether it's ok or there is dyspnea or suffocation due to complete adduction of the true vocal cords.
 - Second thing we check is the voice production, if the injury was on both sides it would be worse because in cases of unilateral injury, the intact remaining nerve can compensate.
- So the cases are:
 1. Unilateral complete section; so one vocal fold is affected so it resides in a position between adduction and abduction, so speech is not greatly affected due to compensation by the other recurrent nerve and respiration is not affected.
 2. Bilateral complete section; voice is affected and respiration is impaired but is not completely blocked, the patient may suffer from dyspnea – difficulty in respiration-.
 3. Unilateral partial section... read it from the slides.
 4. Bilateral partial section; most dangerous, at first the patient suffers from dyspnea then suffocation occurs due to adduction of the vocal cords and rima glottidis becomes very narrow, so we need to do tracheostomy in order to restore the passage of air.

Tracheostomy:

There are several sites to do tracheostomy:

1. Above the isthmus of the thyroid between first and second tracheal rings, and is usually done during operations.
2. Suprasternal, done in emergencies and has some complications, especially that there are blood vessels in the suprasternal notch such as the thyroidema artery, inferior thyroid vein, jugular arch and anterior jugular vein, but we don't care about their injury & bleeding as much as we care about restoring the breathing and delivering oxygen to the brain cells.

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