

RESPIRATORY SYSTEM

ANATOMY



Title: Sheet 4 – Larynx 2

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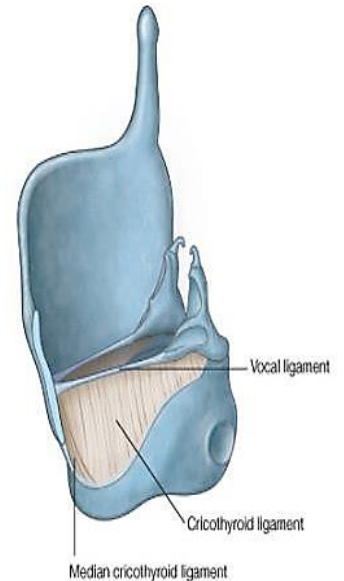
Intrinsic ligaments

The fibro-elastic membrane of the larynx that links the cartilage together and completes the architectural framework of the laryngeal cavity.

It is composed of two parts: a lower **cricothyroid ligament** and an upper **quadrangular membrane**.

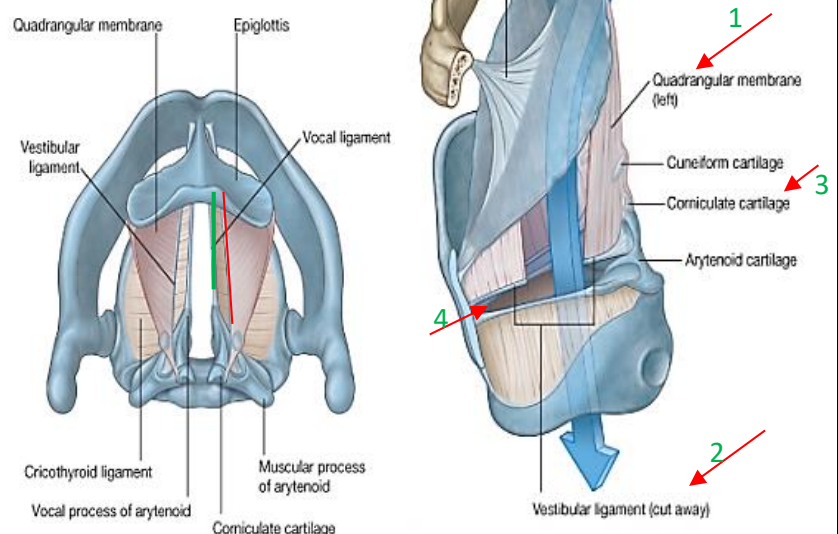
1. Cricothyroid ligament

- Also named the cricovocal membrane, cricothyroid membrane or **conus elasticus**.
- Originates from the arch of cricoid cartilage and extends superiorly to end in a free upper margin within the space enclosed by the thyroid cartilage.
- The upper free margin thickens and attaches to the vocal process of the arytenoid cartilage posteriorly, and the angle of thyroid cartilage anteriorly, forming the **vocal ligament**, which is under the vocal fold (true vocal cord) of the larynx.
- The cricothyroid ligament is also thickened anteriorly in the midline to form the **median cricothyroid ligament**.
- In emergency situations, the median cricothyroid ligament can be perforated to establish an airway.



2. Quadrangular ligament¹

- Originates from the lateral margin of the epiglottis and attaches to the anterolateral surface of arytenoid.
- The free upper margin extends from the aryepiglottic fold. The free lower margin thickens and forms the vestibular ligament² under the vestibular fold (false vocal cord).
- Attaches to the corniculate cartilage³.
- The vestibular ligament is separated from the vocal ligament below by a gap⁴.
- When viewed from above, the **vestibular ligament** is lateral to the **vocal ligament**.





Muscular Intruder:

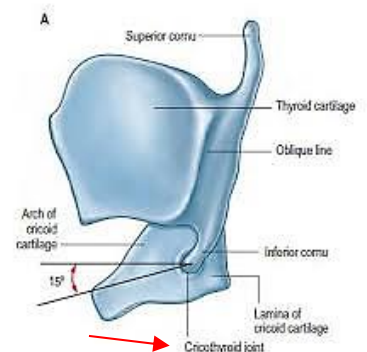
All muscles of the larynx are intrinsic and innervated by the recurrent laryngeal nerve, except for one lonely extrinsic muscle: the **cricothyroid muscle**. It is innervated by the external laryngeal nerve and is responsible for the high-pitched voice by tensing the true vocal cord.

* The doctor said that the cricothyroid muscle is important.

♥ Laryngeal joints (synovial joints)

1. Cricothyroid joints:

- Formed between the cricoid cartilage and the inferior horn of thyroid cartilage. It is surrounded by a capsule and is reinforced by associated ligaments.
- It enables the thyroid cartilage to move forward and tilt downwards on the cricoid cartilage. This movement effectively lengthens and puts tension on the vocal ligaments.



2. Cricoarytenoid joints:

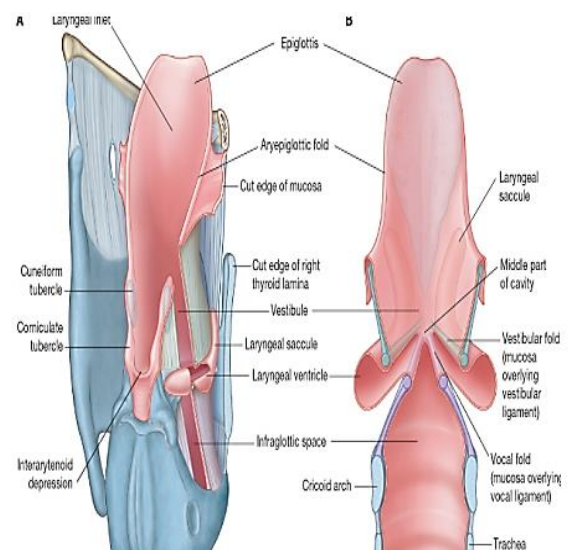
- Formed between articular facets on the superolateral surfaces of the cricoid cartilage and the bases of the arytenoid cartilages
- The crico-arytenoid joint is a synovial pivot joint and it has a rotatory movement for arytenoid over cricoid cartilage. So if the joint moves **internally** (toward the midline) the vocal cord (lateral cricoarytenoid muscle) adducts. If it moves **externally** the vocal cord (posterior cricoarytenoid muscle) abducts.



(This animation may be useful to imagine this joint movement: <https://www.youtube.com/watch?v=k9n9az3hfeY>)

♥ Laryngeal cavity

- The central cavity of the larynx is tubular in shape and is lined by mucosa.
- Support is provided by the fibro-elastic membrane of the larynx and by the 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.



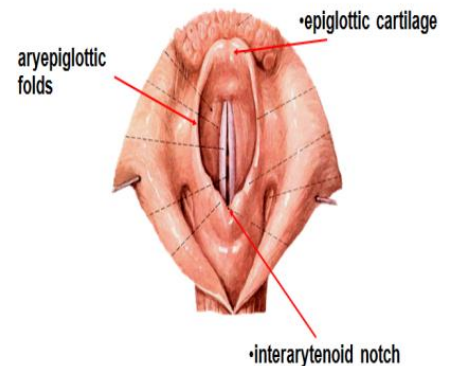
As we've said before, the closure of the inlet is controlled by the larynx moving upwards and the epiglottis moving backwards and downwards aided by the aryepiglottic muscle and the transverse arytenoid muscle.

**The closure is important in deglutition, as we don't want any food particles to reach the airway, or else a coughing reflex will be initiated.

Borders of the inlet:

- ✓ **Anterior border:** Formed by mucosa covering the superior margin of the epiglottis.
- ✓ **Lateral borders:** Formed by mucosal folds (aryepiglottic folds).
- ✓ **Posterior border:** In the midline it is formed by a mucosal fold that forms a depression (inter-arytenoid notch) between the two corniculate tubercles.

Laryngeal cavity
inlet of larynx — bounded by upper border epiglottic cartilage, aryepiglottic folds and interarytenoid notch



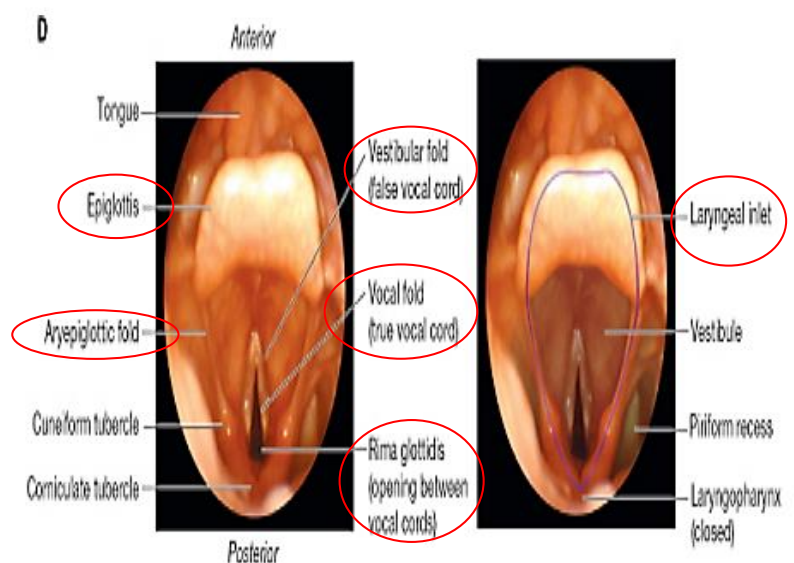
This view ↓ clearly shows the true vocal cords and the inlet between them would take you to the glottic part (rima glottidis) of the larynx (more about it in the next sheet).

Now, why is this important?

Sometimes, patients may go under anesthesia and will be unable to breath on their own during surgery, or they may be too sick or injured to provide enough oxygen to the body without assistance. So, **intubation** is done. In this procedure, a tube is inserted through the mouth right into the trachea through the larynx. Now, when you pass the tube through the larynx, you have to make sure you insert it through the rima glottidis to make sure that the airway stays open.

Aryepiglottic folds:

- Enclose the superior margins of the quadrangular membranes and adjacent soft tissues.
- Two tubercles on the more posterolateral margin side mark the positions of the underlying cuneiform and corniculate cartilages. (See page 5)



Larynx 2

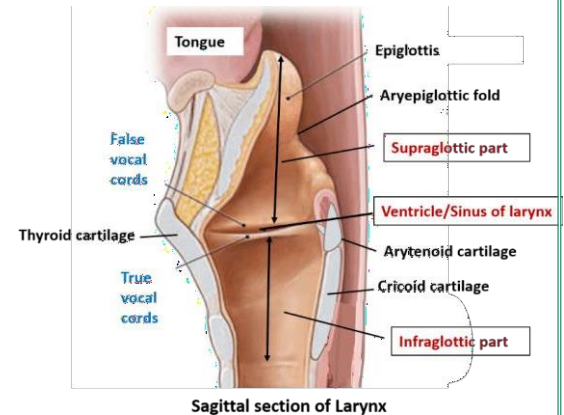
• LARYNX:

Is a **box** of 9 cartilages, with 3 single and 3 **paired** cartilages

- › It's important for passage of air, production of voice, coughing, lifting of heavy objects and others.
- › It has a **cavity**, that we'll study in the coming pages.

The vestibular and vocal folds [more about them throughout this sheet] divide the larynx into three major regions:

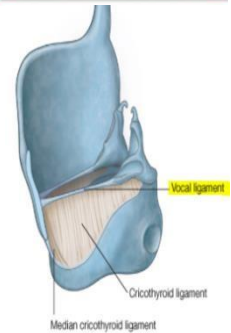
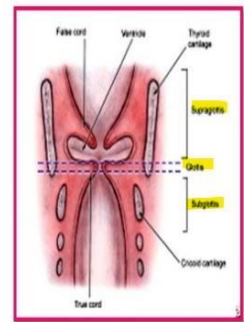
1. Vestibule: begins with the **inlet of larynx** to the **false vocal cords**.
2. Middle (glottic) part: continues from the **false** vocal cords to the **true** vocal cords. On its lateral side there is a **ventricle** [more about it in the coming discussion]
3. Infraglottic part: starts from the **true** vocal cords and leads to the **trachea**.



Internal cavity of the larynx

divided into 3 spaces:

- Supraglottic,
- Glottic, And
- Subglottic spaces



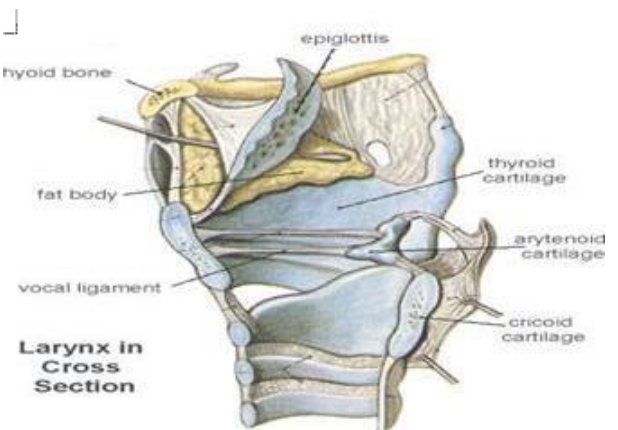
▮ TRUE VOCAL CORDS (A.K.A VOCAL FOLDS):

let's go through their characteristics ➡

- › They consist of **Vocal ligaments**: What is that and where does it come from?

💡 **remember:** It's the **thickened, upper free edge of the cricothyroid membrane** (*conus elasticus*)!!

It extends on each side of the larynx, between **the vocal process of the arytenoid** and the **back of the anterior lamina of thyroid cartilage** <angle of thyroid cartilage> try to follow on the pic

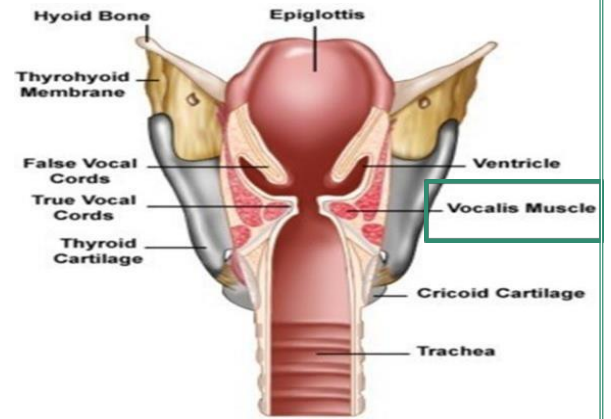


- › The lining epithelium of vocal cords' mucous membranes is **stratified squamous non-keratinized**

< This is of Allah's creativeness, as we humans need this cord to be mitotic and *regenerable* because it is prone to injury by speech or excessive use بالعامية لما يروح صوتك >

So, because of the stratified squamous epithelium, loss of voice is temporal.

- › They have **Vocalis muscles** (thyroarytenoid muscle): to be discussed later in this sheet :D
- › They have **no submucosa**: all respiratory tissue does have submucosa but it's absent here; that's to *prevent* accumulation of fluid in them which cause *edema* that could lead to adduction of vocal cords and suffocation. So, absence of submucosa is an *advantage* here ☺
- › **white in color**: vocal folds have no blood vessels and are supplied by diffusion from the surrounding connective tissue.



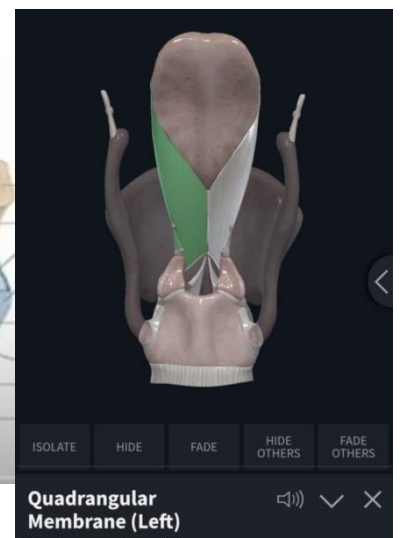
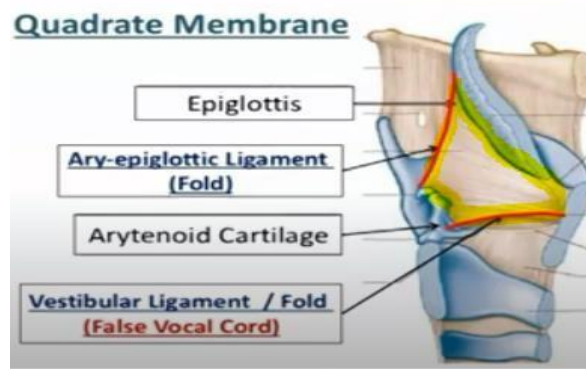
Remember! Difference of voice pitch between genders: females have **shorter** length of vocal cords, more obtuse angle and higher pitch of voice while males have **longer** length with an acute angle and lower pitch of voice

● VESTIBULAR FOLDS (AKA FALSE VOCAL CORDS):

They are formed by the lower free edge of **quadrangular membrane**. Have a look at the beautiful pictures!

Unlike the true vocal cords, vestibular folds are:

- › Vascularized (i.e. red in color)
- › Fixed and not movable



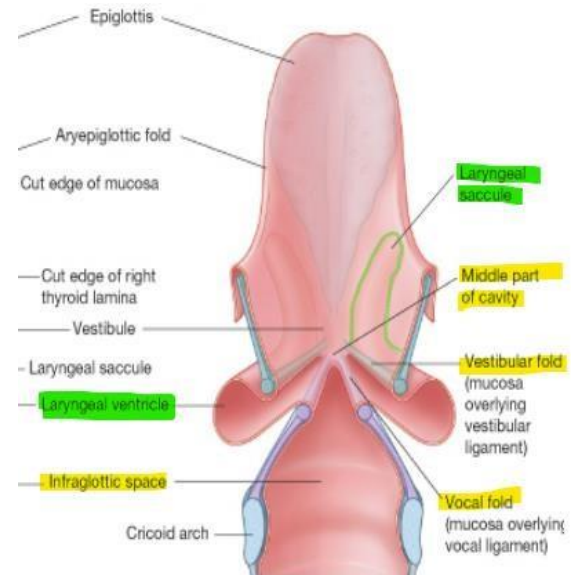
- › **Superior to the vocal cords**
- › Are covered by respiratory mucosa (pseudostratified columnar)

• LARYNGEAL VENTRICLES AND SACCULES

On each side, the mucosa of the middle cavity bulges laterally through the gap between the vestibular and vocal ligaments to produce a laryngeal ventricle.

The importance of this ventricle is that it has a **tubular extension** (like a diverticulum) that will form the **laryngeal saccule** which projects antero-superiorly between the **vestibular fold** and **thyroid cartilage**

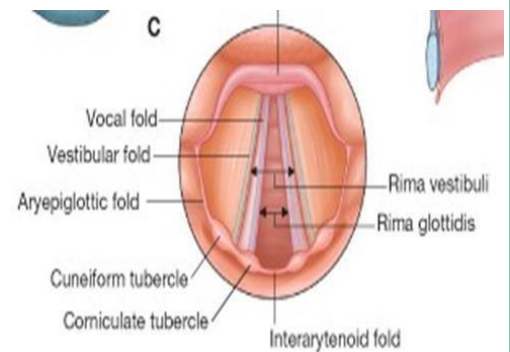
- ➡ Here's the catch: Within the walls of these laryngeal saccules are **numerous seromucous glands** from which secretions flow down to lubricate the true vocal folds (cords).



• RIMA VESTIBULI AND RIMA GLOTTIDIS

The Rima vestibuli: is the space between the false vocal cords.

The Rima glottides: it is the space between the true vocal cords and the **narrowest** point in the laryngeal cavity. Also, it is **the opening which separates the middle chamber above from the infra-glottic cavity below.**

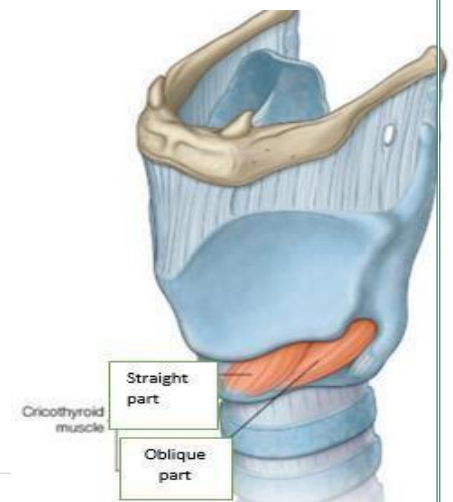


• INTRINSIC MUSCLES OF THE LARYNX:

1. **Cricothyroid muscle:** (usual EXAM QUESTION)

Remember, it is the only EXTERNAL muscle.

Origin and insertion: In general, this muscle moves from the cricoid to the thyroid. It has two parts, oblique^① and straight^②.



- › The oblique part runs in a posterior direction from the arch of cricoid to the inferior horn of thyroid. [notice them on the picture above]
- › The straight part runs more vertically and upward from the arch of the cricoid to the posteroinferior margin of the thyroid lamina

Nerve supply: THE ONLY MUSCLE SUPPLIED BY the EXTERNAL LARYNGEAL N.
All other coming muscles are supplied by RECURRENT LARYNGEAL N.

Action: Pulls the thyroid cartilage forward and rotate it down relative to the cricoid cartilage. These actions **tense** vocal cords.

2. Posterior and lateral cricoarytenoid muscles:

Origin: posterior cricoarytenoid originate from the **posterior surface** of cricoid lamina.

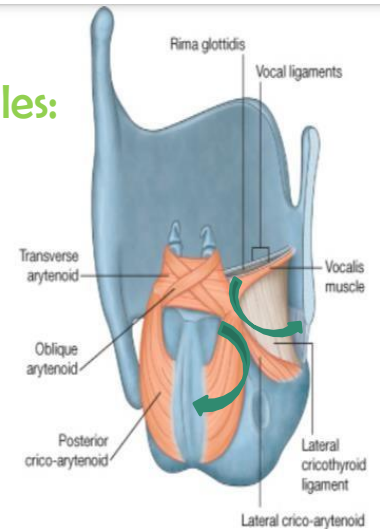
The lateral cricoarytenoid muscle originates from **lateral surface** of cricoid lamina.

Insertion: both bind to the muscular process of arytenoid

Nerve supply: recurrent laryngeal nerve.

Action: pulling the lateral cricoarytenoid muscles internally adducts the vocal cords, while pulling the Posterior cricoarytenoid externally backwards and upwards and by so abducts the vocal cords

notice the curved arrows in this additional picture to the right to help you imagine the action

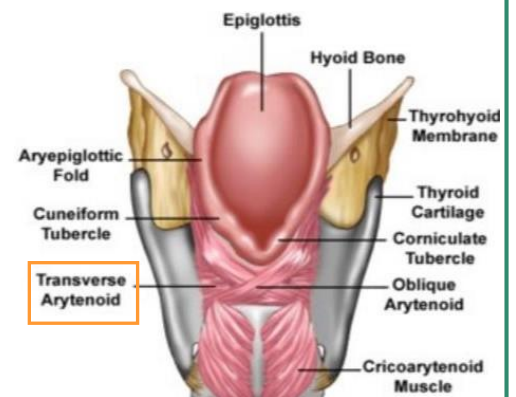


3. Transverse arytenoid

Origin: runs transversely from one arytenoid to the other arytenoid. <slides: Originates from Back and medial surface of arytenoid cartilage and insert in the Back and medial surface of opposite arytenoid cartilage>

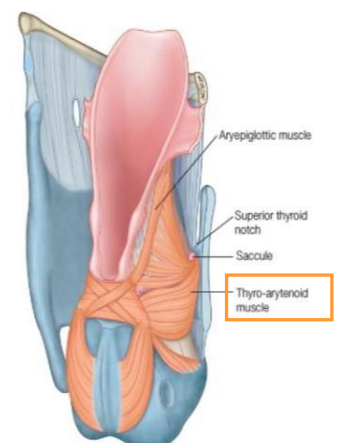
Action: Closes posterior part of rima glottidis by approximating arytenoid cartilages (interarytenoid area).

Now check out this cool animation about previous muscles <3
<https://youtu.be/DXZZpMwPeJ4>



4. Thyroarytenoid (vocalis muscle)

It's a striated muscle and a part of true vocal cords, it **relaxes the true vocal cords**



↪ opposing cricothyroid muscle effect (cricothyroid is a TENSOR, vocalis is a RELAXATOR of the vocal cord)

↪ This muscle is responsible for low pitch of voice while cricothyroid is responsible for the high pitch

5. Oblique arytenoid <see above pictures>

Origin: from the muscular process of one arytenoid to the apex of the opposite arytenoid.

Action: narrow the inlet by adducting aryepiglottic folds.

6. Aryepiglotticus muscle

Origin: between arytenoid and epiglottis, it lies within the aryepiglottic fold

Action: widening of the laryngeal inlet by the abduction the aryepiglottic folds when acting ALONE, but it narrows the inlet when acting with oblique arytenoid I.e. its normal physiological action is aiding in closure of the inlet

● CLOSURE OF THE INLET OF THE LARYNX IN DEGLUTITION:

↪ The food bolus pushes the epiglottis downward and backward, the larynx moves upward, and aryepiglottic muscles along with oblique arytenoid muscle contracts. These events result in adduction of the aryepiglottic folds together and closure of the laryngeal inlet.

The table below summarizes some of the muscles actions:

Adjust tension in the vocal ligaments	Open and close the rima glottidis	Closure of the inlet of the larynx
Tensor- cricothyroid muscle	Adduction- lateral cricoarytenoid	Oblique arytenoid
Relaxation- Thyroarytenoid muscle(vocalis)	Abduction- posterior cricoarytenoid	Right and left aryepiglotticus muscles

● EXTRINSIC MUSCLES OF THE LARYNX

Remember from GI system, they are classified into **suprahyoid and infrahyoid** muscles → Suprahyoid muscles pull the larynx upward and aid inclosureof inlet.

→ Infrahyoid muscles depress the larynx downward.

Suprahyoid muscles:

- › Digastric
- › Stylohyoid
- › Mylohyoid
- › Geniohyoid
- › Assisted by Stylopharyngeus, Salpingo-pharyngeus, and Palatopharyngeus

Infrahyoid muscles:

- › sternothyroid
- › sternohyoid
- › omohyoid

Remember: Functions of the larynx:

- › Deglutition or swallowing < closure of the inlet during swallowing >
- › Respiration < through which the larynx is relaxed >
- › Phonation < vibration of true vocal cords during expiration as the two vocal cords are adducted causing compressed column of air to be partitioned >
- › Effort closure: during heavy lifting, vocal cords are adducted completely, thus a column of air is formed beneath the vocal cords and it gives efforts for lifting heavy objects then after lifting there would be a deep expiration

BLOOD SUPPLY OF THE LARYNX:

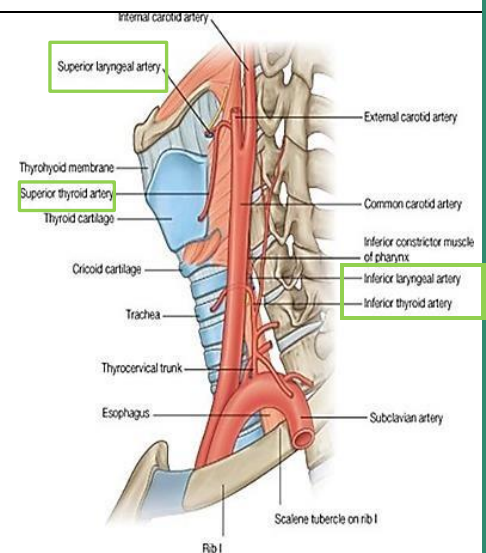
1. **Superior laryngeal artery:** which pierces the thyrohyoid membrane with the **internal laryngeal nerve** – the latter is sensory to the larynx above vocal cords and a branch of the vagus.

➔ chain: external carotid A. → superior thyroid A. (runs with ext. laryngeal N.) → superior laryngeal A.

2. **Inferior laryngeal artery:**

chain: Subclavian artery → thyrocervical trunk → inferior thyroid → inferior laryngeal.

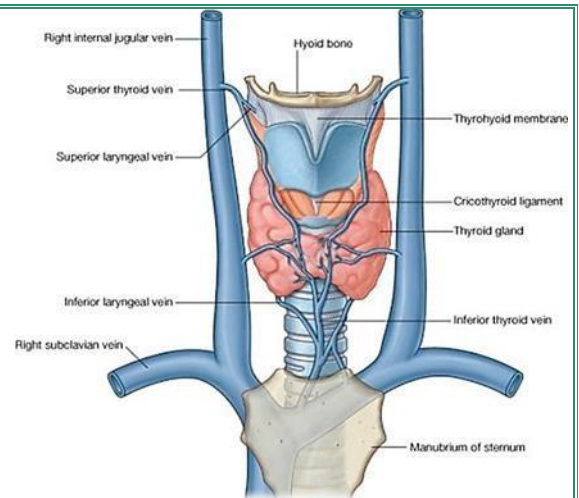
↪ **Recurrent laryngeal nerve** passes between the branches of the inferior thyroid artery and then with the inferior laryngeal artery. Together, they ascend in the groove between the esophagus and trachea, entering the larynx by passing deep to the margin of the inferior constrictor muscle of the pharynx.



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● VENOUS DRAINAGE OF LARYNX

- **Superior laryngeal vein** → drains into superior thyroid vein → internal jugular vein
- **Inferior laryngeal vein** → inferior thyroid vein → left brachiocephalic vein.
- **The inferior thyroid vein** ends in the left brachiocephalic and not in the right because the left is more oblique and longer



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● LYMPHATIC DRAINAGE OF THE LARYNX

The lymphatic drainage is divided to above and below the true vocal cords:

- Above** the true vocal cords, lymphatics end in the deep cervical lymph nodes through the lymph nodes associated with superior laryngeal artery.
- Below** the true vocal cord, lymphatics drain into the lymph nodes associated with inferior thyroid artery and ends in paratracheal lymph nodes (on the cricothyroid ligament or upper trachea)

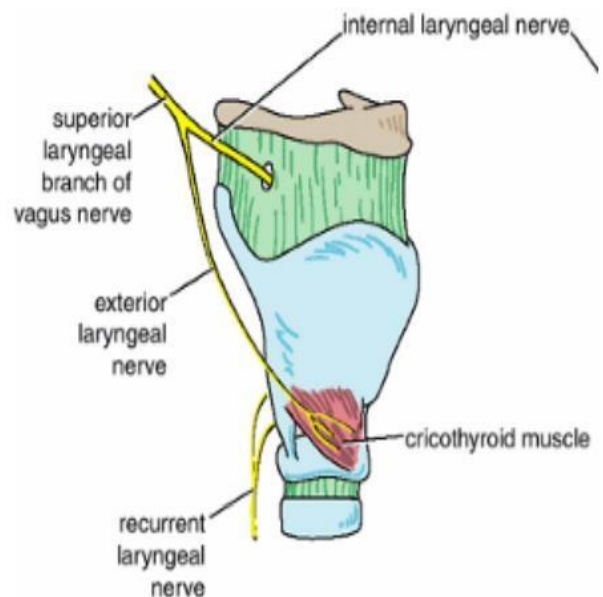
● INNERVATION OF THE LARYNX

Generally speaking, the innervation of the larynx is divided to motor and sensory; above and below the true vocal cords:

↪ **Sensory** innervation to the mucosa **above** the true vocal cords by **internal laryngeal nerve**.

↪ **Sensory** innervation **below** the true vocal cords by the **recurrent laryngeal nerve**.

↪ Motor innervation to all laryngeal muscles is by the **RECURRENT LARYNGEAL NERVE** [exception: cricothyroid which is supplied by the external laryngeal nerve a branch of the superior laryngeal of the vagus]

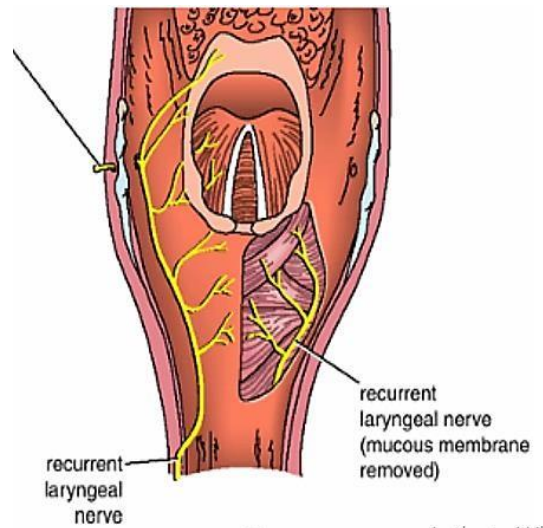


Recurrent laryngeal nerves: branches of the vagus

The left recurrent nerves are longer [take a wild guess why, does CVS remind you of sth here? :P]:

The left vagus nerve (which is longer) descends to the thorax and gives the left recurrent laryngeal nerve **below the arch of aorta** which then ascends between trachea and oesophagus to the larynx.

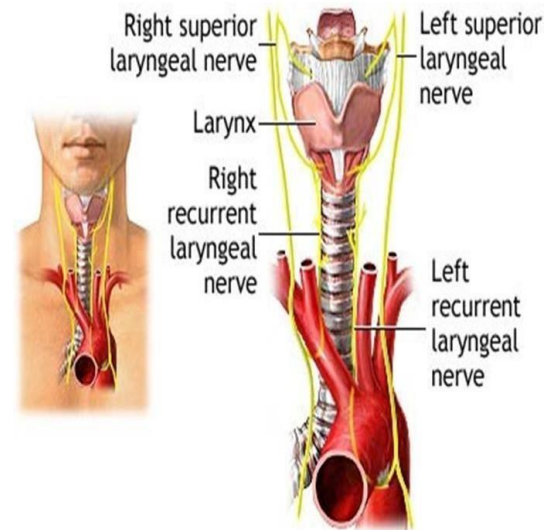
The right vagus nerve gives the right recurrent nerve at the root of the neck, **below the subclavian vessels**.



↳ So, the right recurrent nerve isn't found in the chest and it's not related to the pleura and lung.

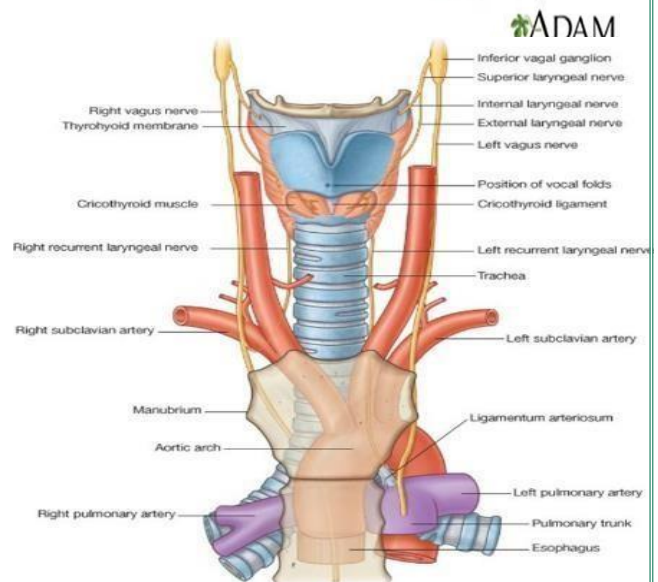
💡 Remember for the thousand time as the doctor kept repeating it, they innervate all the muscles except the cricothyroid, they are also sensory to the mucosa below true vocal cord

This picture to the right is a previous lab question, it's important to differentiate between the right and left recurrent nerve ----->



• RELATIONS OF THE LARYNX

- **Laterally:** The carotid sheath and its contents which are: the common carotid artery, internal jugular vein and vagus nerve. In addition to the lateral lobes of thyroid.
- **Posteriorly:** pharynx and right recurrent laryngeal nerve
- **Anteriorly:** Skin, fascia and 4 infrahyoid muscles.



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• CLINICAL NOTES

NOTE 1: During thyroidectomy and ligation of **superior thyroid artery** the **external laryngeal nerve** could be injured. Bilateral injury to the external laryngeal nerve result in bilateral paralysis of cricothyroid muscle and hoarseness and unilateral causes weakness of the voice (due to loss of the ability to tense vocal cords completely).

NOTE 2: Injury to the recurrent laryngeal nerve could be bilateral complete section, bilateral partial section, unilateral complete section or unilateral partial section (section as in cut). As discussed in the following:

General notes on recurrent laryngeal nerve injury:

- **Logically, there are two important things to look at after recurrent nerve injury: respiration and speech.**
- **Partial injury:** injury to *superficial fibers* (deep fibers are spared) that supply the *abductor* muscles due to manipulation or tension. Partial injury results in adduction of vocal folds and causes suffocation if it was bilateral. It is more dangerous than complete because in complete injury vocal cords are neither adducted nor abducted.
SO, most dangerous form is partial bilateral due to suffocation, tracheostomy should be performed.
- Unilateral partial of recurrent causes hoarseness of voice, while unilateral complete injury of recurrent doesn't affect speech

Forms of recurrent laryngeal nerve injury:

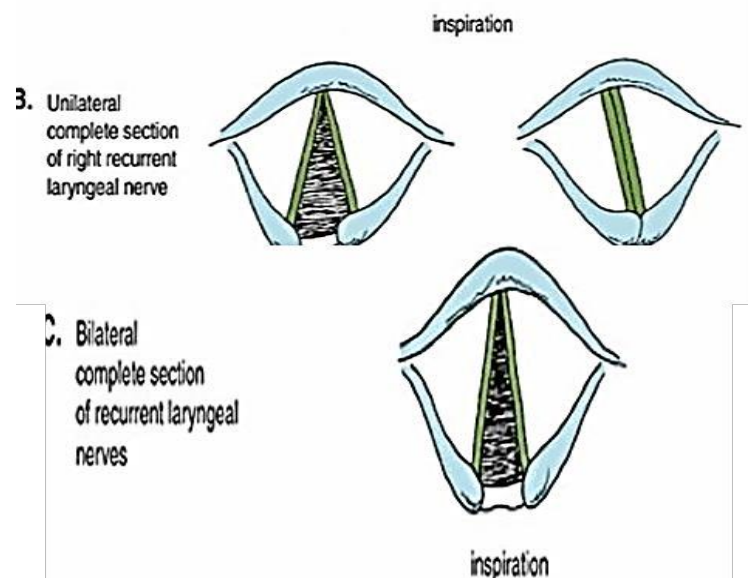
› Unilateral Complete section:

One vocal fold (on the affected side) would be stuck in the position midway between abducted and adducted states

Speech and respiration **aren't much affected** because the *other side* compensates.

› Bilateral complete section: difficulty in breathing without suffocation,

rima glottidis is partially closed and the **speech is lost** as both cords are affected.



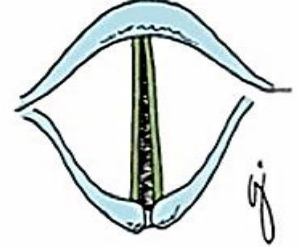
- › **Unilateral partial section: hoarseness in voice** with **difficulty in respiration**.
- › **Bilateral partial section: dyspnea, stridor (snoring) and suffocation**.
Most serious, here the tracheostomy is a necessity

D. Unilateral partial section of right recurrent laryngeal nerve



inspiration

E. Bilateral partial section of recurrent laryngeal nerves



inspiration

"وقل رب زدني علماً"

-سورة طه