THE LARYNX

- **<u>Valve</u>** which protects the entrance to the airway (tracheobronchial tree)
- Also involved in phonation (speech)
- Laryngeal incompetance → aspiration of food & fluid

- Composed of 4 major cartilages united by mobile synovial joints
- Has an outer and inner wall which rise from a circular base – the cricoid ring – like 2 flower pots, one placed inside the other.

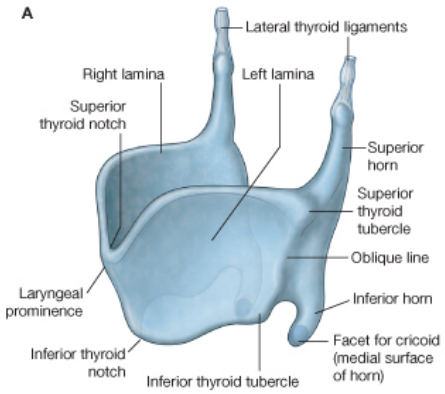
CARTILAGES AND MEMBRANES OF THE LARYNX

<u>Outer wall:</u>

- **Thyroid cartilage + thyrohyoid membrane**
- **Cricoid cartilage + cricothyroid membrane**

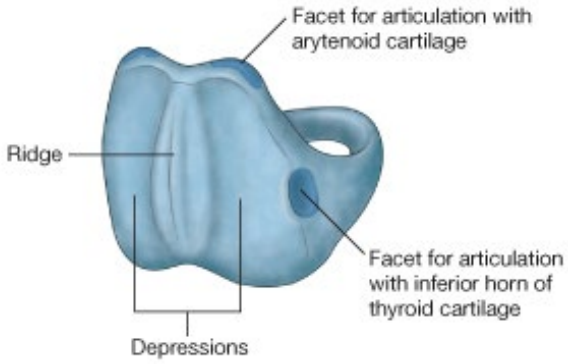
Thyroid cartilage:

- Thyroid cartilage is the largest – consists of 2 **laminae** which meet in the midline at an angle
- Thyroid cartilage projects as a <u>laryngeal prominence</u> – seen and palapated in midline of neck – especially in men (as angle between the 2 laminae becomes more acute in puberty).
- **Superior thyroid notch** can be palpated between the 2 laminae above the laryngeal prominence
- Posterior border of thyroid cartilage is extended above and below as **superior & inferior horns (cornau).**



Cricoid cartilage:

- Shape of signet ring
- Narrow part lies in front, expanded part lies behind.
- Narrow front can be palpated in midline of neck below the thyroid cartilage
- Inferior cornu of each thyroid lamina articulates with a facet on the side of the cricoid by a synovial joint.

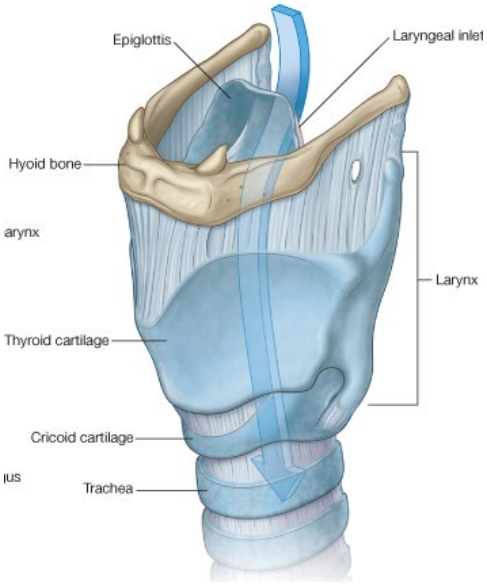


Membranes:

- **Thyrohyoid membrane:**
  - Upper border of each lamina of thyroid cartilage
  - → inner margin of hyoid bone above

- **Cricothyroid membrane:**
  - Lower border of thyroid cartilage
  - → cricoid in the midline

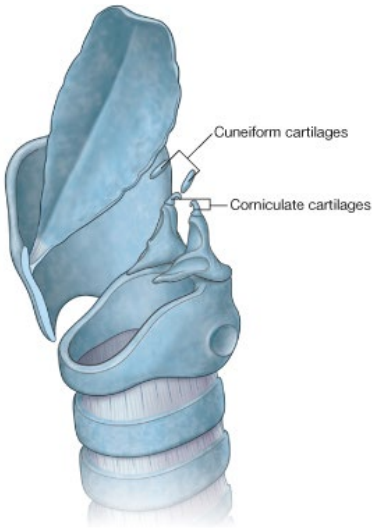
- **Cricotracheal ligament:**
  - Lower border of cricoid
  - Uppermost ring of trachea

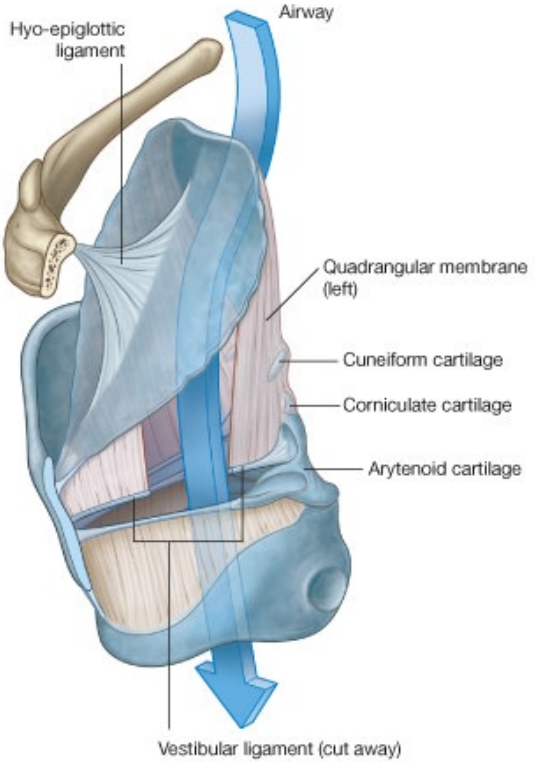


<u>Inner wall:</u>

- Composed of
  - Membrane
  - Muscle
  - **Arytenoid cartilage** posteriorly
  - **Epiglottis** above

- **Epiglottis** is leaf-like and attached to the inner angle of the thyroid laminae by a ligament.
- Projects upwards behind the thyrohyoid membrane, hyoid bone & tongue.
- <u>Paired</u> **arytenoid cartilages** sit on upper border of the lamina of the cricoid, by <u>synovial joint</u>.
- Each arytenoid is pyramidal in shape





Quadrangular membrane + vestibular ligament

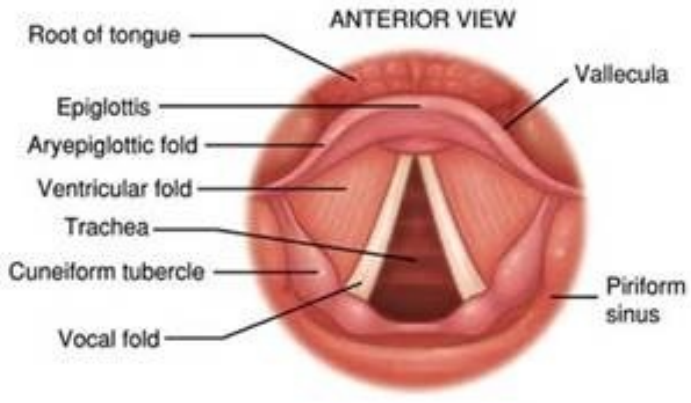
- Inner wall is complete by **quadrangular membrane**
- Passes between the sides of the epiglottis above → arytenoids
- The bottom of the quadrangular ligament forms a sharp free border between the arytenoids behind and the thyroid lamina in front – the **vestibular ligament** (false cords)
- There is a slit-like gap below the vestibular ligament
- The upper part of quadrangular membrane is less well developed, and is replaced by muscle fibres.

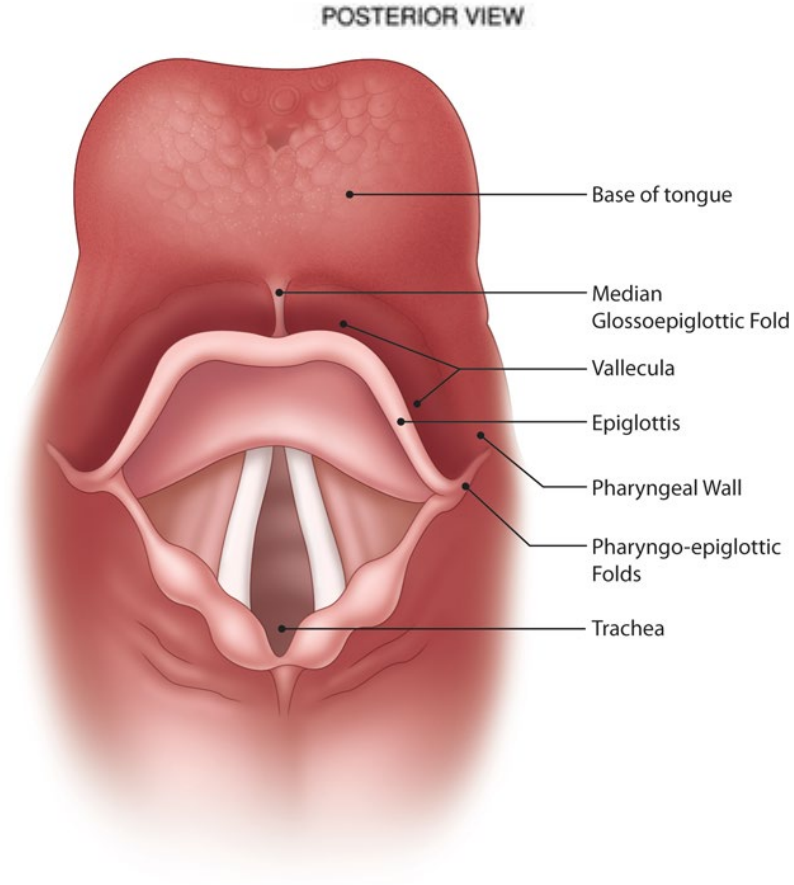
Cricovocal membrane + vocal ligament

- Below the slit formed by the vestibular ligament is the **conus elasticus** (**cricovocal membrane)**.
- **Conus elasticus:**
    - Arises from circular cricoid base
    - Ends at an upper free border – forming the lower edge of the slit (top edge formed by vestibular ligament).
    - The free edge runs between:
        - Posteriorly: **anterior process (vocal process)** of the arytenoid cartilage
        - Anteriorly: midline of the 2 thyroid laminae
        - Thickened free edge is called the **vocal ligament.**
        - When covered with mucus membrane it is called the **vocal fold (vocal cord)**

- The thyroid, cricoid and most of the arytenoid cartilages are hyaline cartilage
- Eppiglottis & apices of the arytenoids = elastic fibrocartilage

- Pea-like **corniculate** and **cuneiform** cartilages are located along the upper border of the quadrangular membrane.





MOVEMENTS OF THE LARYNGEAL CARTILAGES:

- It is the **vocal ligaments** which are responsible for:
    - Production of sound
    - Airway size
- Movement of cricothyroid joints and cricoarytenoid joints change the tension of the vocal ligaments.

Cricothyroid joint – changes <u>tension</u> of the vocal ligaments

- Tilt thyroid cartilage forwards → increased tension of vocal ligaments
- Tilt thyroid cartilage backwards → decreased tension of vocal ligaments.

Cricoarytenoid joints – <u>abducts/adducts</u> the vocal ligaments:

- Allow the arytenoid cartilages to move towards or away from each other

- Δ move the vocal ligaments away from, or towards the midline.

- The vocal folds also move away from each other on deep inspiration (due to trachea stretching downwards).

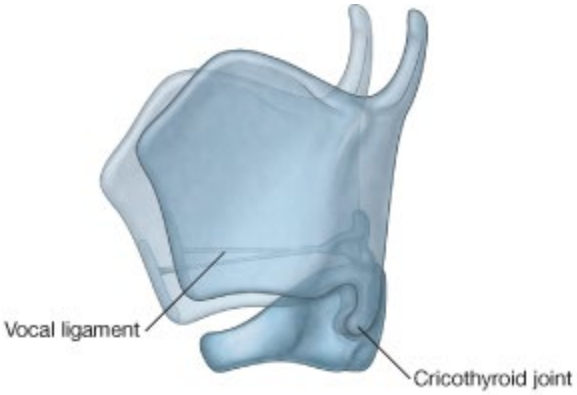
- The gap between the vocal ligaments is called the **rima glottidis** – alters in size and shape on adduction/abduction of arytenoids & on deep breathing.

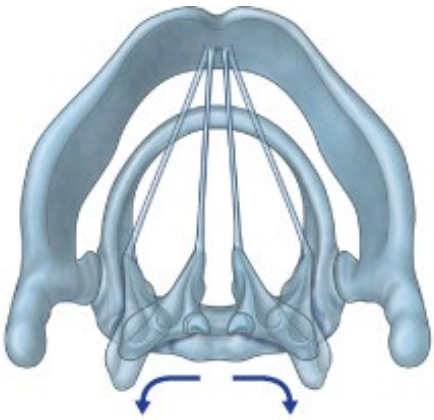
- The cricoarytenoid joints are cyclindrical in nature.
- Also allow rocking of the arytenoids forwards and backwards on the cricoid:
- *Rock forward:* reduced tension in vocal ligaments
- *Rock backwards*: increased tension in vocal ligament

- **Intrinsic muscles** are responsible for moving the cricothyroid and cricoarytenoid joints.

- **Extrinsic muscles** connect the larynx to surrounding structures – moving the larynx as a whole up and down within the neck

- **Intrinsic muscles** can be split into 3 functional groups:
    - Move the epiglottis and close the laryngeal inlet
    - Abduction/adduction of the cords
    - Tension of the cords





MUSCLES OF THE LARYNGEAL INLET

- **Aryepiglottic muscle:**
    - Extends from apex of the arytenoid ligament and loops round epiglottis
    - Travels in **aryepiglottic fold**

- **Oblique arytenoid muscles**:
    - Continuation of the aryepiglottic muscle onto the arytenoid cartilage on the opposite side.
    - Cross over one another behind the arytenoid cartilages

- Aryepiglottic muscle + oblique arytenoid muscles form **sphincter of the inlet** of the larynx
- Contraction brings **aryepiglottic folds** together & brings epitglottis closer to arytenoid cartilages.

- **Thyroepiglottic muscles**:
    - Sweep from inside of thyroid cartilage → epiglottis on each side
    - Contraction opens the inlet of the larynx.

- Strong sphincteric action of the larynx can resist high intrathoracic pressures.

MUSCLES WHICH ABDUCT AND ADDUCT THE CORDS:

- Abduction / adduction of vocal folds (vocal cords) → changed volume of air passing through larynx.
- Independent of the intrinsic muscles, movement of the trachea on deep breathing and activity of the sternothyroid muscle will both cause abduction of the vocal cords.

- **Posterior cricoarytenoid muscles**:
    - Arise from back of cricoid
    - Converge on **muscular process** of the arytenoids (**lateral angle** of arytenoid).
    - Cause abduction of the vocal folds:
        - Dispute as to whether they laterally rotate the arytenoids on a vertical axis, or whether they slide the whole arytenoid outwards.
    - Posterior cricoarytenoids also resist the pull of the cricothyroid muscle (without this opposition from behind, the arytenoids would fall forwards on contraction of the cricothyroid muscle).
    - Assist in creating tension in the vocal ligaments by pulling back on the arytenoids.
    - Open the airway

- **Lateral cricoarytenoid muscles:**
    - Arise from lateral side of cricoid
    - Run obliquely to muscular process of arytenoid
    - Adducts the vocal folds

- **Transverse arytenoid muscle:**
    - Passes horizontally from one arytenoid to the other at the back of the larynx.
    - Adducts to vocal folds.

MUSCLES WHICH TENSE AND RELAX THE VOCAL LIGAMENTS:

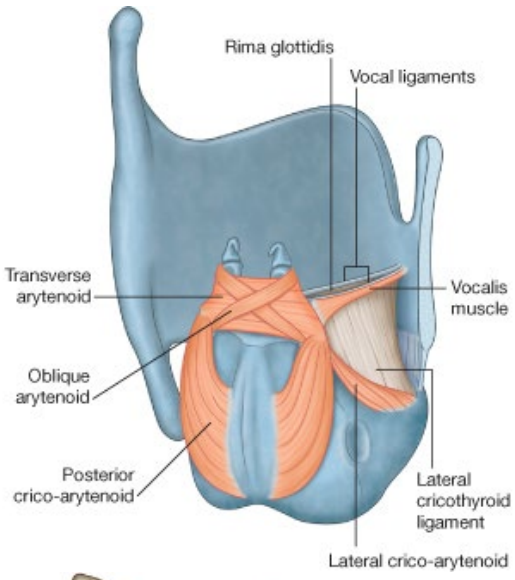
- Changing tension → change in pitch of the voice

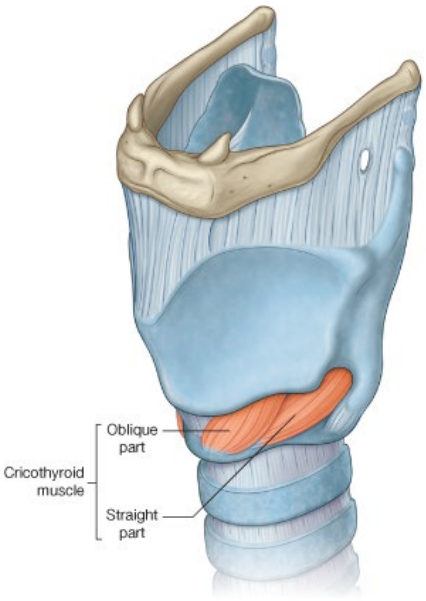
- **Thyroatenyoid muscle:**
    - Arises from interior midline angle of the thyroid cartilage
    - Sweeps back to insert into anterolateral surface of arytenoid cartilage.
        - Draws the atenyloid cartilages forwards and **relaxes** the vocal ligament.

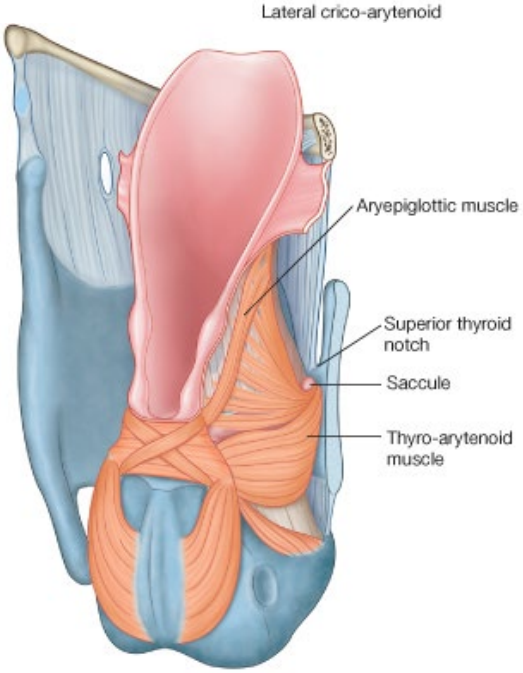
    - **Vocalis** is a deep triangle bundle of thyroatenyoid muscle – is able to selectively abduct part of the vocal ligament whilst the rest remains adducted.
    - Important in producing sounds of the highest pitch.

- Some of its fibres insert into the epiglottis as the **thyroepiglottic muscle** – widening the laryngeal inlet.

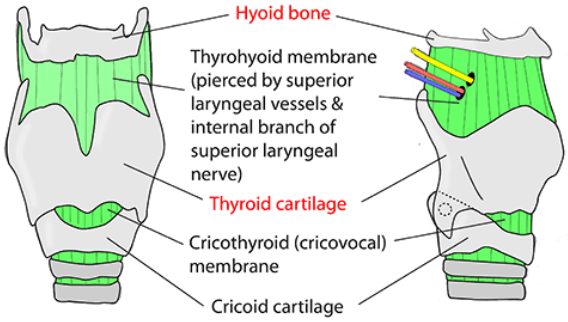
- **Cricothyroid muscle:**
  - Opposes the pull of the:
    - Posterior cricoarytenoid muscle
    - Thyroarytenoids
  - Lie on the outer surface of the larynx
  - <u>Pulls the thyroid cartilage fowards</u>
  - Produce **<u>tension</u>** in the vocal ligaments.
  - Involved in production of high voice tones

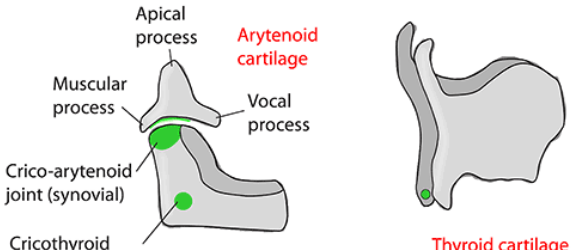






LARYNX - BONES/CARTILAGES





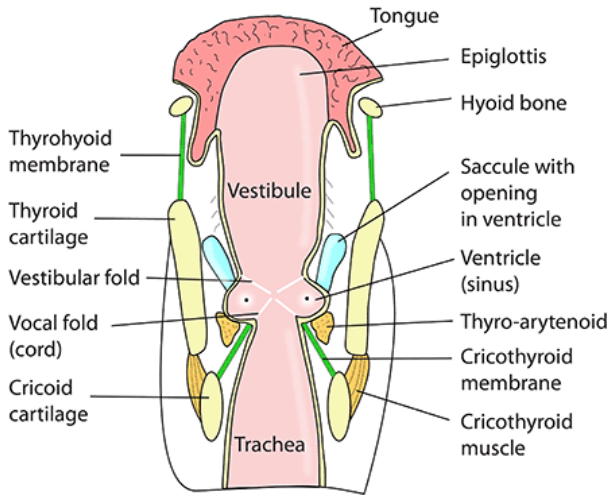
Cricoid cartilage
- Signet ring like
- Complete ring of cartilage

Thyroid cartilage
- Shield like

Larynx elevated by: Mylohyoid, digastric, stylohyoid, geniohyoid, thyrohyoid, stylopharyngeus, palatopharyngeus, salpingopharyngeus, inferior constrictor

LARYNX - CORONAL SECTION

Viewed from behind so looking anteriorly



Blood supply: Superior & inferior laryngeal arteries

Mucosa: Pseudostratified ciliated columnar. Mucous glands in sinus (cords & top of epiglottis - stratified squamous)

Nerve supply:
- Sensory above cords - Internal branch of superior laryngeal n
- Sensory below cords - Recurrent laryngeal n
- Motor to muscles - From nucleus ambiguus via cranial accessory
  - to: Cricothyroid - External branch of superior laryngeal n
  - to: All other laryngeal muscles, including upper oesophagus & cricopharyngeus - recurrent laryngeal nerve

Lymphatic drainage:

Above cords - upper deep cervical nodes

Below cords - lower deep cervical nodes

LARYNX - CRICOTHYROID MUSCLE

CRICOTHYROID has 3 special features that makes it different from other laryngeal muscles. These are:

- It is the only muscle that tightens the cords
- It is supplied the external branch of the superior laryngeal nerve and not the recurrent laryngeal
- It is the only intrinsic muscle of the larynx which on the outside of larynx

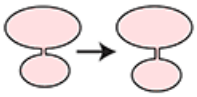
LARYNX - FUNCTION AND DEVELOPMENT

DURING SWALLOWING

- Closure of aditus by aryepiglotticus acting like a purse-sting on the aryepiglottic folds
- Closure of rima glottidis/cords (lateral crico-arytenoids & transverse arytenoids)
- Epiglottis flips backwards/downwards with solid food
- Larynx/pharynx hauled up under the tongue (suprahyoid muscles)

DURING PHONATION

- Cords held together for up to 3mm
- Vocalis helps to change the amount of cord that approximates
- Series of jets of air
- Resonance produced by structures above larynx (pharynx/sinuses)
- Whispering is very wasteful of air as it is a constant stream



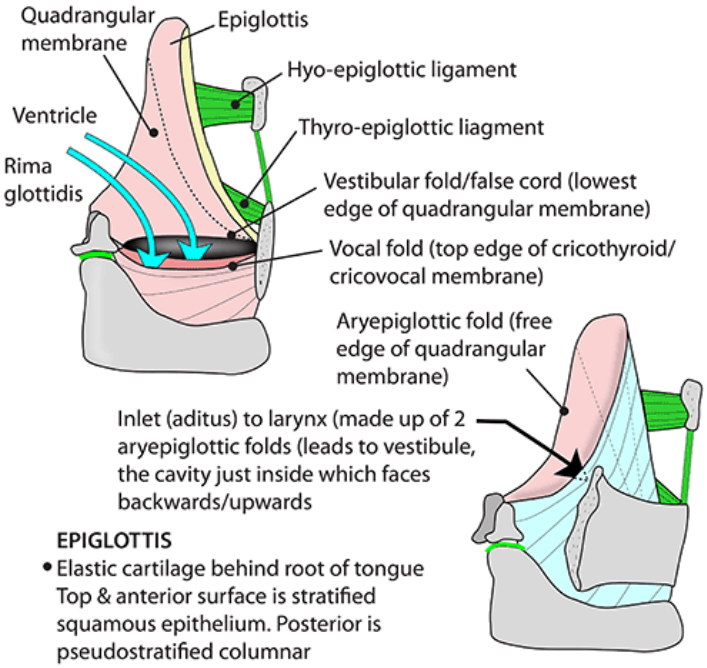
DURING COUGHING AND STRAINING

- Explosion of compressed air via closed cords

LARYNX - INLET & EPIGLOTTIS

Inlet:

- Extends from tip of epiglottis to C6
- Open for respiration, partially closed for speaking, closed for coughing, straining and swallowing
- Hangs from hyoid bone via tongue/mandible (hyoglossus, mylohyoid geniohyoid, digastrics, middle constrictor). Some effect on it by 3 of 4 strap muscles (omohyoid, sternohyoid & thyrohyoid)

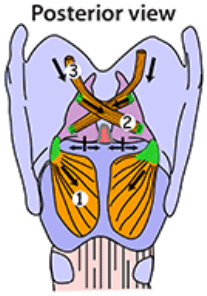


EPIGLOTTIS

- Elastic cartilage behind root of tongue Top & anterior surface is stratified squamous epithelium. Posterior is pseudostratified columnar
- Held by: hyo-epiglottic, thyro-epiglottic & aryepiglottic ligaments & median & lateral glosso-epiglottic folds

LARYNX - INTRINSIC MUSCLES

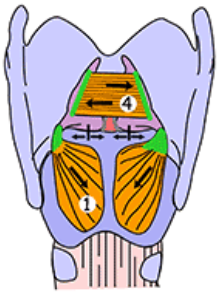
Posterior view



Posterior crico-arytenoid (1) abducts & opens cords

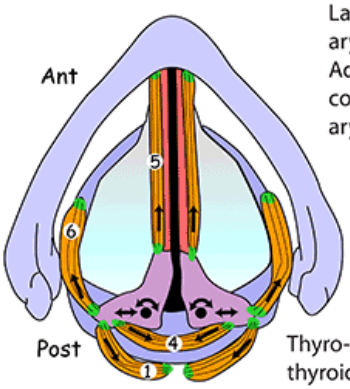
Oblique arytenoids (2) close cords by drawing together arytenoids. They extend into aryepiglottic fold as ary-epiglotticus (3) to close the aditus

Posterior view



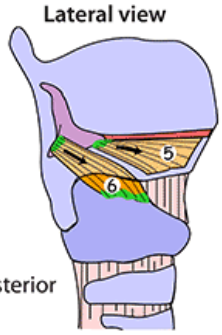
Transverse arytenoid (4) closes cords by drawing together arytenoids

Looking down at cords



Lateral crico-arytenoids (6) Adduct/close cords by rotating arytenoids medially

Lateral view



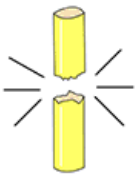
Thyro-arytenoids (5) loosen cords by pulling the thyroid cartilage towards the arytenoids. Vocalis is part of this muscle and changes the shape of the cords

SEMON'S LAW
FOR DAMAGE OF NERVES TO LARYNX

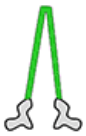
Semon's Law indicates the different effect between damage & transection of the recurrent laryngeal nerve as applicable to surgery in the region of this nerve (eg thyroidectomy or parathyroidectomy). It is probably more of a guide than a rule

Transection of recurrent laryngeal nerve

RLN



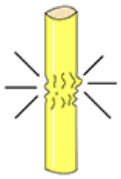
CORDS



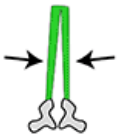
- Complete paralysis
- 1/2 ab(ad)ducted
- Cannot cough or speak

Trauma but no transection

RLN



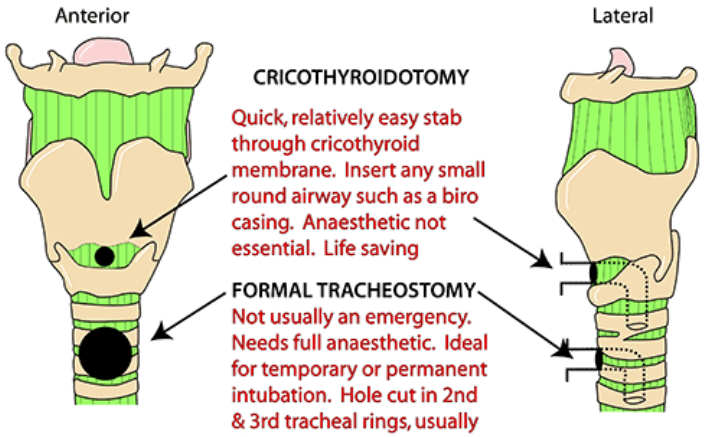
CORDS



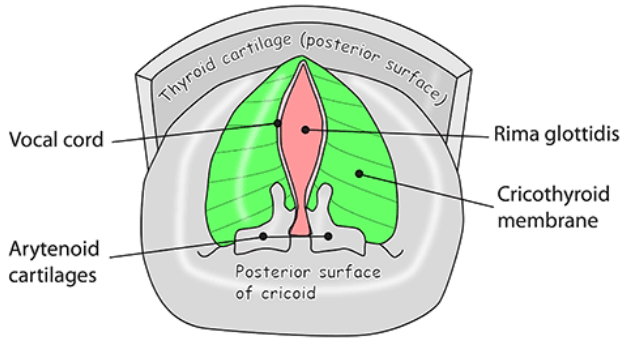
- Partial paralysis
- Adducted cords
- Posterior crico-arytenoids most vulnerable
- Cannot breath

BILATERAL → DISASTER
UNILATERAL → CAN COMPENSATE

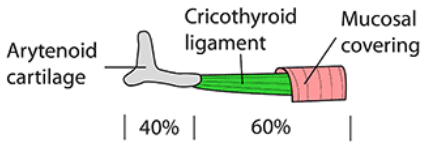
EMERGENCY ACCESS TO TRACHEA



VOCAL CORDS/CRICOTHYROID MEMBRANE



TRUE VOCAL CORDS are the free upper edges of the crico-thyroid membrane (conus elasticus) where it is thickened to become the cricovocal liagment and covered with mucosa. The mucosa is pearly white and has no submucosa and thus cannot become oedematous
40% of the vocal cord is arytenoid cartilage
60% is membrane
The cricothyroid membrane is attached around the inside of the ring of cricoid cartilage and has a free upper margin that is attached to the arytenoid cartilages posteriorly and to the back of the thyroid cartilage anteriorly



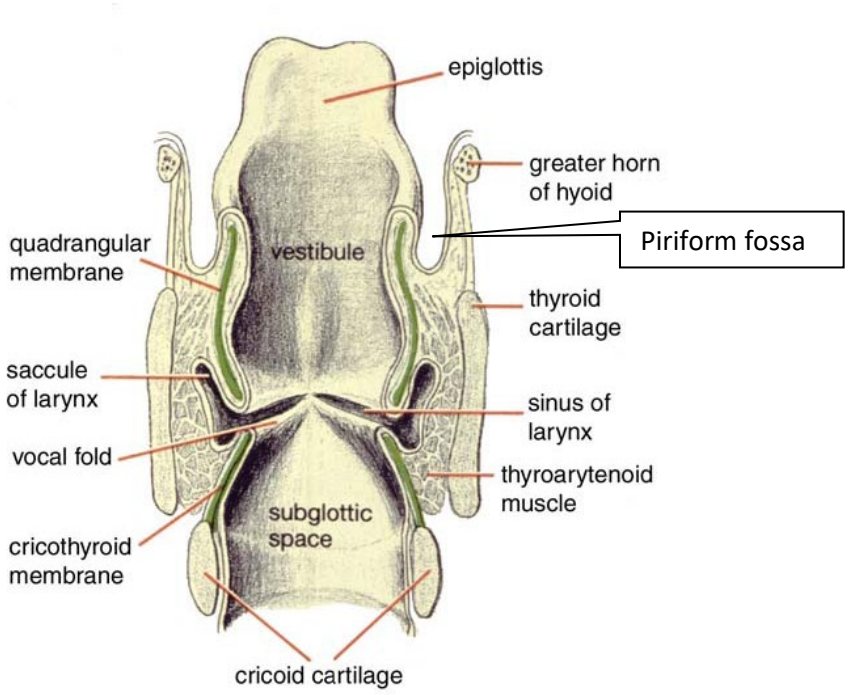
THE INTERIOR OF THE LARYNX

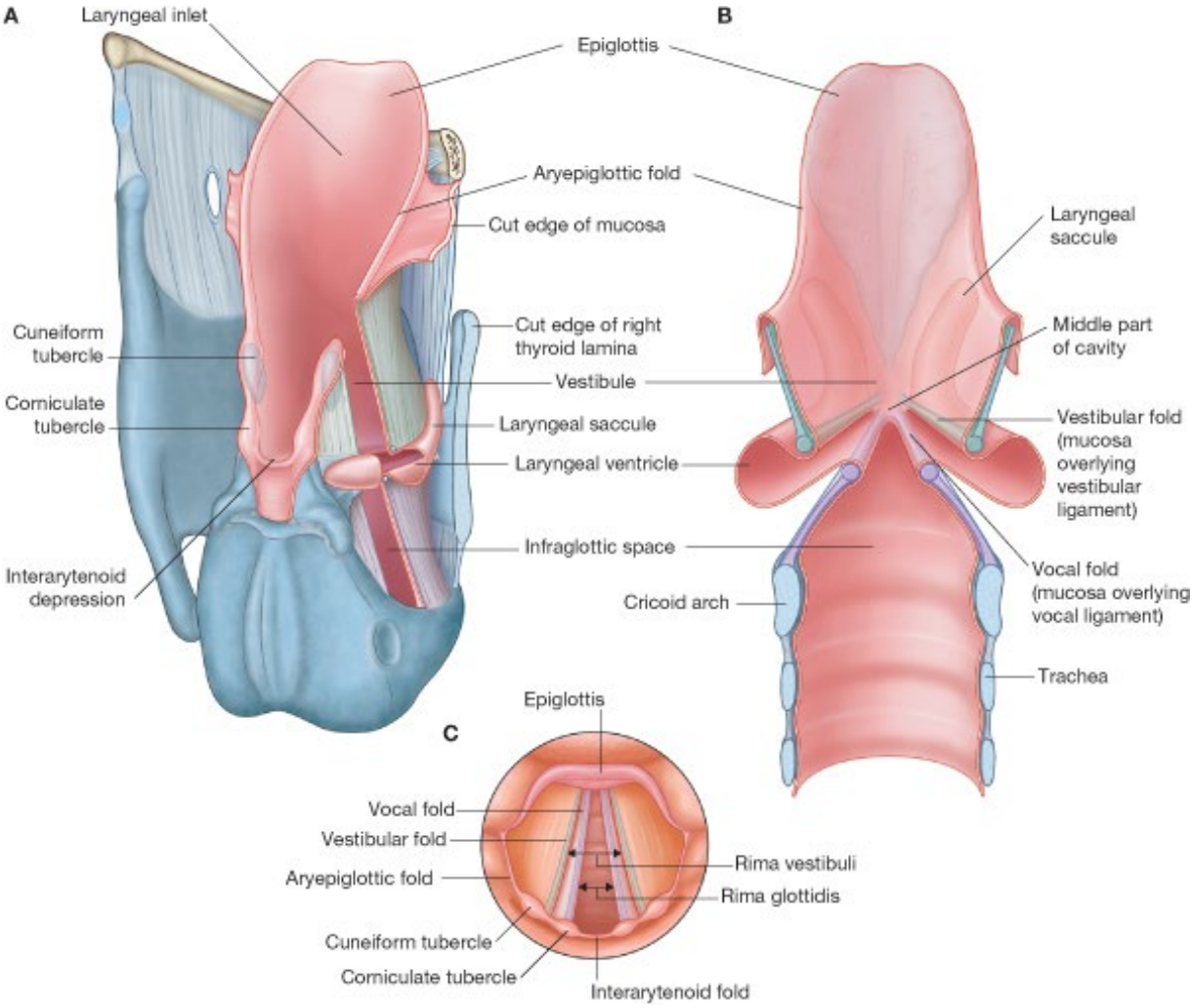
- Lined with mucus membrane
- Mucous membrane reflected from the tongue onto the epiglottis
- The <u>mucous membrane</u> is thrown into **one median** and **two lateral glossoepiglottic folds**.
- Depression either side of the median fold is the **vallecula**

- Between the outer and inner walls of the larynx, the mucus membrane forms a **piriform recess/fossa** on each side.

- Inlet of the larynx is almost vertical and leads into the **vestible** – the upper part of the larynx
- Vestible extends from inlet down to the vestibular ligaments (base of the quadrangular membrane)
- The gap between the 2 vestibular folds (vestibular ligaments covered with mucous membrane) is the **rima vestibuli**.

- Between the vestibular folds and the vocal folds is a gap leading to the **<u>ventricle of the larynx</u>**.
- Most anterior aspect of the ventricle of the larynx is the **saccule of the larynx**.
- The **ventricle and saccule extend <u>upwards</u> on the outside of the quadrangular membrane**.


epiglottis
greater horn of hyoid
Piriform fossa
quadrangular membrane
vestibule
thyroid cartilage
saccule of larynx
sinus of larynx
vocal fold
thyroarytenoid muscle
subglottic space
cricothyroid membrane
cricoid cartilage



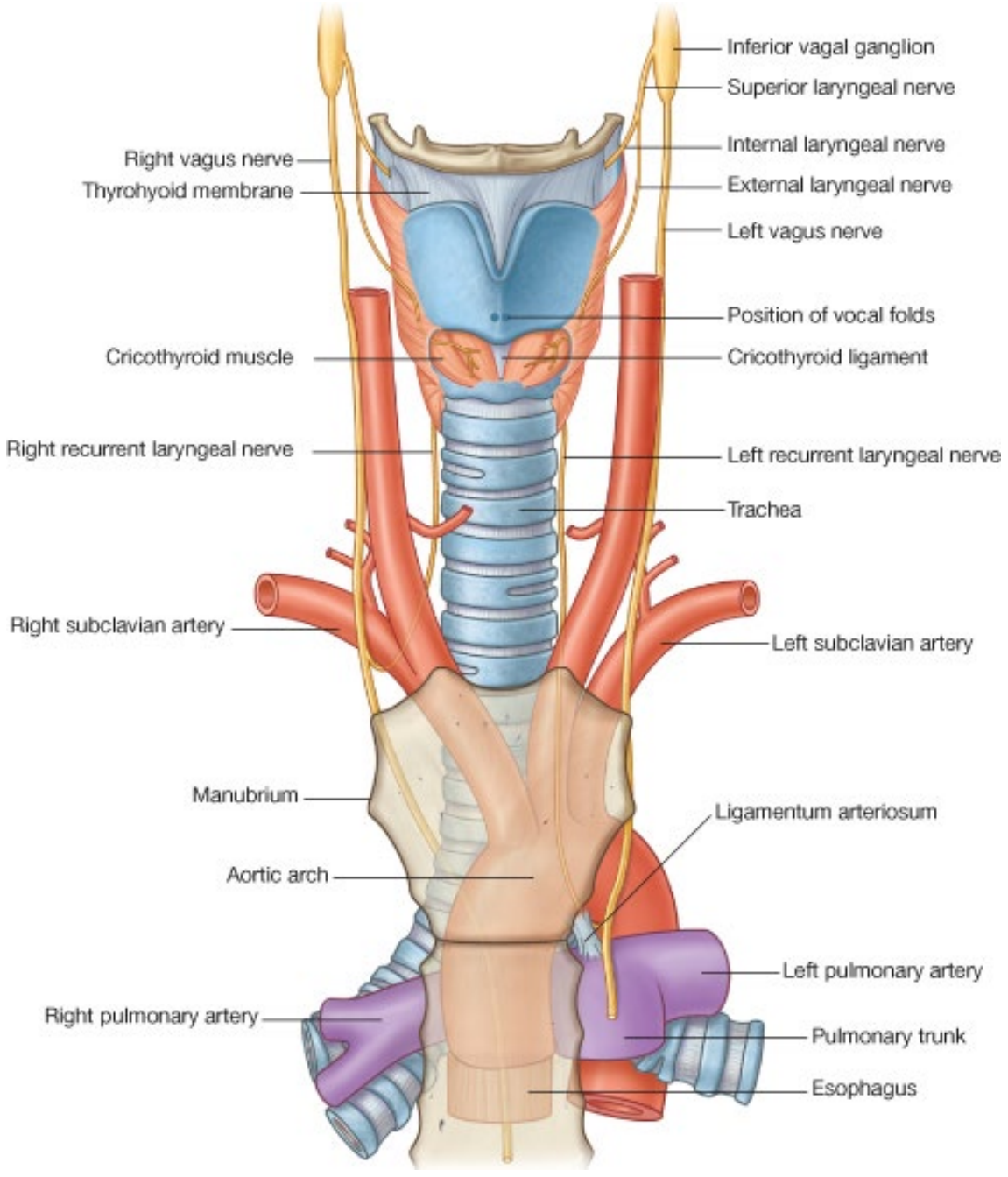
NERVES TO THE LARYNX

- From the **<u>vagus nerve (X)</u>:**
  - **Superior laryngeal nerve**
  - **Recurrent laryngeal nerve**

- **<u>Superior larygneal nerve</u>** leaves the vagus high in the neck
- Passes deep to both carotids
- Divides into internal and external branches
  - **Internal laryngeal nerve - <u>sensory</u>**
    - Pierces thyrohyoid membrane
    - Enters larynx
    - Supplies **sensation** to:
      - Mucous membrane above the vocal cords (including piriform fossa)
      - Both surfaces of epiglottis
      - Aryepiglottic fold
      - Each vallecula
  - **External laryngeal nerve - <u>motor</u>**
    - Supplies cricothyroid muscle
    - <u>Closely associated with superior thyroid artery</u> in its course.

- **Recurrent laryngeal nerve**
- Enters larynx behind the cricothyroid joint
- Supplies:
  - All of the intrinsic muscles of the larynx *except* cricothryoid muscle
  - Mucus membrane below the vocal cords.
- The terminal branches of the recurrent laryngeal nerve mix with those of the superior laryngeal nerve.
- Closely associated with inferior thyroid artery.

- Cricopharangeal part of inferior constrictor of pharynx is also supplied by the reccurent laryngeal nerve of superior laryngeal nerve.



LYMPHATIC DRAINAGE OF THE LARYNX:

- Important in metastasis of cancer
- 2 distinct systems of lymphatics in the larynx:
  - One above the vocal cords
  - One below the vocal cords
- The 2 systems anastomose in the posterior larynx.

Upper group: ***upper deep cervical nodes***

- Lymphatics from upper group pierce the thyrohyoid membrane and follow the superior laryngeal vessels.
- Reach the **upper deep cervical nodes**

Lower group: ***lower deep cervical nodes***

- Pierce the cricovocal membrane
- Drain into:
  - **Pretracheal nodes** on cricovocal membrane
  - **Paratracheal nodes** along recurrent laryngeal nerve

APPLIED ANATOMY OF THE LARYNX:

- An open airway is essential for life.

- Most common obstruction to the airway results from food / other objects getting lodged in the laryngeal inlet.
- Accompanied by spasm of the larangeal muscles → occlusion of airway.
- Obstruction can normally be removed by coughing / using fingers / heimlich
- In an eregency, an incision can be made through the cricothyroid membrane in the midline – lies below the level of the vocal cords at the entrance to the trachea.

- Food can sometimes get stuck in the piriform fossa and must be removed

- Anaesthetists must be able to recognise the valleculae at the base of the tongue when intubating patients.
- Tip of laryngoscope is placed in the valleculae, and base of the tongue drawn forward to bring the larnyngeal inlet into view
- Once in clear view, a tube can be placed through the **rima glottidis** into the trachea

Damage to vagus nerve (X)

- Lesion of the vagus nerve → complete paralysis of larynx & loss of sensation

Damage to recurrent laryngeal nerve

- Injury to one of the recurrent laryngeal nerves → *paralysis of all intrinsic laryngeal muscles except cricothyroid*
- → vocal cord fixed in adducted / abducted position.
- If fixed in adducted position → breathlessness (dyspnoea) on exertion
- If fixed in abducted position → complaint will be more of hoarseness & weakness of voice

- Bilateral damage to the recurrent laryngeal nerves → adduction of both cords → hoarsness & dyspnoea.

Damage to the superior laryngeal nerve

- Loss of sensation of mucous membrane above the vocal cords
- Results in paralysis of the cricothyroid muscle
- Voice is hoarse due to slackness of the vocal cords.
- Difficulty in reaching high notes, and voice tires quickly
- Recovery often occurs as the opposite cord and muscle adapts.

- Can insert a tube into the cricothyroid membrane in an emergency to bypass a blockage (if the blockage is above the level of the vocal folds).