

Embryology of Larynx

Development of larynx

- During the 4th week of intra uterine life.
- Starts in the form of laryngotracheal groove in the ventral wall of the pharynx.
- The groove gradually deepens and its edges fuse to form a septum, this septum separates the laryngotracheal tube from the pharynx and oesophagus.
- The process of this fusion starts caudally and extend cranially.
- Lined with endoderm from which the epithelium of the airway develop.
- The cranial end of this laryngotracheal tube forms the larynx and the trachea.
- Caudally this tube produces two branches from which the two main bronchi develop.
- This is also the place from which the two lung buds starts to develop.
- Any congenital malformation of the pharynx and oesophagus is always associated with certain degree of malformation of larynx and trachea.
- Primitive larynx is the cranial part of the laryngo tracheal groove.
- It is bounded by the caudal part of the hypobranchial eminence and laterally by the ventral folds of the sixth branchial arches.
- Epiglottis develops from the hypobranchial eminence.
- Arytenoid swellings appear on either side of the laryngo tracheal groove, as they enlarge they become approximated with each other and to the caudal portion of the hypobranchial eminence.
- This development converts the vertical slit of the laryngeal cavity into a T shaped one.
- Initially the walls of the cleft adhere to each other occluding the laryngeal cavity. During the third month of intrauterine life the lumen is restored by dissolution of the clump of cells occluding the cavity.
- The nerves supplying the 4th and 6th arches (superior and recurrent laryngeal nerves supply the larynx)

<table>
<thead>
<tr>
<th>Name of the cartilage</th>
<th>Developed from</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thyroid cartilage</td>
<td>Ventrals ends of 4th arch cartilage</td>
</tr>
<tr>
<td>Arytenoids</td>
<td>6th arch</td>
</tr>
<tr>
<td>Corniculate</td>
<td>6th arch</td>
</tr>
<tr>
<td>Epiglottis</td>
<td>Hypobranchial eminence</td>
</tr>
<tr>
<td>Cricoid &amp; Tracheal cartilages</td>
<td>6th branchial arch</td>
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Anatomy of the Larynx

Introduction:

- Situated above the trachea. Extends from the laryngeal inlet to the inferior border of the cricoid cartilage. Opposite the third to sixth cervical vertebrae, being a little higher in women than in men.

The infantile larynx:

- Smaller than the adult compared to body size. More funnel shaped. Its narrowest part is at the junction of the subglottic larynx with the trachea and even slight swelling in this area may result in marked airway obstruction. Cartilages are much softer and collapse more easily on forced inspiration. The larynx starts high up under the tongue in early life and with age assumes an increasingly lower position in the neck. The size of the larynx is almost the same in boys and girls till puberty. After puberty the antero posterior diameter of the larynx virtually doubles in males.
The larynx is divided anatomically into:

- Supra glottis
- Glottis
- Sub glottis

By the falls and true vocal cords.

The supraglottis consists of superiorly the epiglottis and aryepiglottic folds as they sweep down to the arytenoids. Its lower border is the ventricular bands (false cords) which form the upper border of the glottis.

The glottis includes the vocal cords and anterior commissure and posterior commissure.

The sub glottis becomes the trachea at the lower border of the cricoid. (Between true v.c. and lower border of the cricoid).

The framework of the larynx

Consists of:

- Hyoid bone
- Number of cartilages
- Connected by ligaments, membranes and intrinsic and extrinsic muscles to give it stability.
- They move in relation to one another by the action of the two groups of muscles.
- Lined with a mucous membrane that is continuous above with the pharynx and below with that of the trachea.

Hyoid Bone

- U-shaped bone.
- Provides the upper attachment for many of the extrinsic muscles of the larynx
- Suspends the larynx in the neck
- It consists of:
  - Body anteriorly
  - Greater cornua project backwards on each side
  - Lesser cornua two small conical eminences attached to the upper part of the body of the hyoid by a fibrous band and sometimes to the greater cornua by way of a synovial joint

Cartilaginous skeleton of larynx

- 9 different cartilages present in the larynx.
  - Unpaired cartilages: (thyroid, cricoid, epiglottis)
  - Paired cartilages: (arytenoid, corniculate, cuneiform)

Thyroid Cartilage

- Shield like. Largest of the laryngeal cartilages.
- Has two laminae meet in the midline inferiorly.
- The angle of fusion between the laminae is about 90 degree in men and 120 degrees in women.
- The fused anterior borders in men form a projection, which can be easily palpated known as Adams apple.
- The laminae diverge posteriorly.
- The posterior border of the two laminae are prolonged as two slender processes known as the superior and inferior cornua.
• The Oblique Line:
  o The oblique line extends from the superior thyroid tubercle to the inferior thyroid tubercle.
  o The oblique line gives attachment to the following muscles:
    1. Thyrohyoid muscle
    2. Sternohyoid muscle
    3. Inferior constrictor muscle
• Ligaments attached to the thyroid cartilage:
  o Thyroepiglottic ligament: elastic ligament connecting epiglottis to angle of the thyroid cartilage.
  o Vestibular ligament: Also known as the false vocal cord.
  o Vocal ligament: Also known as the true vocal cord is responsible for the generation of voice.

Cricoid Cartilage
• The only complete cartilage ring in the whole of the respiratory pathway.
• Shaped like a signet ring.
• Composed of a deep broad quadrilateral lamina posteriorly and a narrow arch anteriorly.
• The lamina of the cricoid cartilage has articular facets for arytenoid cartilage. These joints are synovial in nature. The cricoid cartilage also articulates with the thyroid cartilage.

The Arytenoid Cartilages
• Small paired cartilages placed close together on the upper and lateral borders of the cricoid lamina.
• Pyramidal shaped.
• Has two projections, forward and lateral projections.
• The forward projection is also known as vocal process. The vocal folds are attached to the vocal process.
• The lateral processes are also known as muscular process.
• The apex of this cartilage curves backwards and articulates with corniculate cartilages. Aryepiglottic folds are attached to these cartilages.

Corniculate and Cuneiform Cartilages
• The corniculate cartilages are two small conical nodules of elastic fibrocartilage which articulate through a synovial joint with the apices of the arytenoid cartilages. They are situated in the posterior part of the aryepiglottic fold.
• The cuneiform cartilages are two small elongated flakes of fibroelastic cartilage, one in each margin of the aryepiglottic fold.

Epiglottis
• Leaf shaped fibroelastic cartilage.
• Projects upwards behind the tongue and the body of the hyoid bone.
• Its upper part is broad and is directed upwards and backwards.
• Superior margin is free.
• The sides of the epiglottis is attached to the arytenoid cartilages by aryepiglottic folds.
• Anterior surface of epiglottis is free & is covered with the same mucous membrane as that of pharynx.
• Forms a single median glossoepiglottic fold and two lateral glossoepiglottic folds.
• Between these folds lie a depression known as the vallecula.
• In neonates and infants the epiglottis is omega shaped.
• This long, deeply grooved, floppy epiglottis protects the nasotracheal air passage during sucking.
Laryngeal joints

- **Crico-thyroid joint**: between thyroid and cricoid cartilages. It’s a synovial joint.
  - Two movements occur:
    - Rotation through a transverse axis.
    - Gliding, slightly.
- **Crico-arytenoid joint**:
  - Between arytenoid and the cricoid cartilage. It’s a synovial joint.
  - Two movements occur:
    - Rotation: of the arytenoid, on vertical axis. The vocal process moves medially or laterally.
    - Gliding: the arytenoid moves toward or away from each other.

Ligaments and membranes of the larynx

- Extrinsic and Intrinsic ligaments.
- **Extrinsic ligaments**: connect the laryngeal cartilages to the hyoid bone above and trachea below.
  - Thyro-hyoid membrane: between the upper border of the thyroid and the body and greater cornua of the hyoid bone.
  - Crico-tracheal ligament: Unites the lower border of the cricoid cartilage with the first tracheal ring.
  - Hyo-epiglottic ligament: connects the epiglottis to the back of the body of the hyoid bone.
- **Intrinsic ligaments**: 
  - Ligaments that connect the laryngeal cartilages.
  - Strengthen the capsule of intercartilagenous joints.
  - Form a broad sheet of fibroelastic tissue which lie beneath the mucous membrane of the larynx creating an internal framework.

The fibroelastic membrane:

- Divided into upper and lower part by the presence of laryngeal ventricle.
- The upper membrane is the quadrilateral membrane.
- It extends between epiglottis and the arytenoid cartilage.
- Its upper margin forms a framework for the aryepiglottic fold.
- Its lower margin is thickened to form the vestibular ligament, which underlies the vestibular fold or false vocal cord.
- The lower part is a thicker membrane, containing many elastic fibers. It is also known as cricovocal ligament or cricothyroid ligament or conus elasticus.
- Below it is attached to the upper border of the cricoid cartilage.
- Above it is stretched between the midpoint of thyroid cartilage anteriorly and the vocal process of the arytenoid behind.
- The free upper border of this membrane forms the vocal cord.

Muscles of the larynx

**Extrinsic muscles** of the larynx connect the laryngeal cartilages to Hyoid bone above and trachea below and maintain the position of the larynx in the neck.

- Divided Into:
  - Infra hyoid group (strap muscles): (Thyrohyoid, Sternothyroid, Sternohyoid, omohyoid).
  - Supra hyoid group (Mylohyoid, Geniohyoid, Stylohyoid, Digastric, Stylopharyngeus, Palatopharyngeus, Salpingopharyngeus)
<table>
<thead>
<tr>
<th>Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
<th>Innervation</th>
</tr>
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<tbody>
<tr>
<td><strong>INFRAHYOID GROUP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sternohyoid</td>
<td>posterir surface of the manubrium sterni and the 1st costal cartilage</td>
<td>lower edge of the body of the hyoid</td>
<td>Draws the larynx downwards.</td>
<td></td>
</tr>
<tr>
<td>Thyrohyoid</td>
<td>oblique line on the thyroid ala</td>
<td>lower border of the greater horn of the hyoid bone</td>
<td>Rises the larynx if the hyoid is fixed. Depress the hyoid if the larynx is fixed</td>
<td></td>
</tr>
<tr>
<td>Sternothyroid</td>
<td>posterir surface of the manubrium and the 1st costal cartilage</td>
<td>Oblique line on the thyroid lamina.</td>
<td>Depresses the larynx</td>
<td></td>
</tr>
<tr>
<td>Omohyoid (inferior belly)</td>
<td>superior border of scapula</td>
<td>intermediate tendon</td>
<td>Depresses the larynx</td>
<td></td>
</tr>
<tr>
<td>Omohyoid (superior belly)</td>
<td>intermediate tendon</td>
<td>Lateral surface of hyoid bone</td>
<td>Depresses the larynx</td>
<td></td>
</tr>
</tbody>
</table>

All of the infrahyoid muscles are innervated by the ansa cervicalis from the cervical plexus (c1-c3) except the thyrohyoid muscle, which is innervated by fibres only from the 1st cervical signal nerve travelling with the hypoglosal nerve.

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<tr>
<td><strong>SUPRAHYOID GROUP</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Mylohyoid</td>
<td>Mylohyoid line on the inner aspect of Mndible.</td>
<td>Midline raphe and body of hyoid.</td>
<td>Raises and pulls the hyoid.</td>
<td>Nerve to mylohyoid (inferior alveolar branch of v3 )</td>
</tr>
<tr>
<td>Geniohyoid</td>
<td>Genial tubercle on Mndible</td>
<td>Upper border of the body of hyoid</td>
<td>Raises and pulls the hyoid forward</td>
<td>Hypoglossal (C1 root)</td>
</tr>
<tr>
<td>Stylohyoid</td>
<td>Back of the styloid (split around digastric process )</td>
<td>Base of greater cornu of thyroid.</td>
<td>Retractor and elevator of hyoid for swallowing.</td>
<td>Facial nerve</td>
</tr>
<tr>
<td>Digastric</td>
<td>Digastric notch on the medial surface Mastoid process.</td>
<td>Lower border of the Mandible .fibrous sling holds the tendon to lesser cornu of hyoid</td>
<td>Anterior belly pulls the hyoid anterior &amp; up Posterior belly pulls hyoid post. &amp; up.</td>
<td>Posterior belly – facial nerve Anterior belly - nerve to mylohyoid</td>
</tr>
<tr>
<td>Palatopharyngeus</td>
<td>Palatine aponeurosis And post. Margin of palat.</td>
<td>Post. Border of thyroid alar and cornu.</td>
<td>Helps tilts the larynx forward</td>
<td>Accessory nerve pharyngeal plexus</td>
</tr>
<tr>
<td>Salpingopharyngeus</td>
<td>Eustachian tube</td>
<td>Post. Border of thyroid cart. (. side wall of pharynx )</td>
<td>Elevates the larynx</td>
<td>Pharyngeal plexus</td>
</tr>
</tbody>
</table>
Intrinsic muscles of larynx

- The intrinsic muscles are all paired and move the cartilages in the larynx and regulate the mechanical properties of the larynx. They control the position and shape of the vocal folds and control the elasticity and viscosity of each layer.

- Divided into:
  - Open & close glottis: (lateral & post. cricoarytenoid muscles, transverse & oblique arytenoids).
  - Control the tension of vocal ligaments: (thyroarytenoids, vocalis and cricothyroids).
  - Alter the shape of the inlet of the larynx: (aryepiglotticus and the thyroepiglotticus).
  - Except transverse arytenoid, all these muscles are paired.

- Abductor of vocal cords: there is only one each side.
  - Posterior cricoarytenoid muscle: is the only muscle that opens the glottis, separating the vocal processes and thus abducts the vocal cords.

- Adductors of vocal cords: three on each side.
  - Lateral cricoarytenoid muscle: Adducts the vocal ligaments by rotating the arytenoids medially.
  - Transvers portion of inter arytenoid muscle: A single muscle. Adduct the vocal cord.
  - External portion of thyroarytenoid muscle: A thin sheet which lies outside the vocal cord, venticle and saccule of the larynx. It closes the rima glottis by medial rotation of Arytenoid cartilage around longitudinal axis.

- Tensors of the vocal cords: 2 on each side.
  - Cricothyroid muscle: The only intrinsic muscle that lie outside the cartilaginous framework of the larynx. It is known as the External tensor.
  - Internal portion of thyro-arypeiglotticus muscle: A specialized portion of the lower and deeper fibers of the thyro-arytenoid muscle. It forms a triangular bundle. Some of its fibers gain its attachment to the vocal ligament. It is known as the internal tensor.

- Opener of laryngeal inlet:
  - Fibers of thyro-epiglottic muscle is a part of the thyro-arytenoid muscle widens the inlet of the larynx by pulling the ary-epiglottic folds slightly apart.

- Closers of the laryngeal inlet:
  - Oblique portion of inter-arytenoid muscle is superficial to the transvers portion. The two bundle of fibers cross each other: closes the rima glottis.
  - Ary-epiglottic muscle is prolongation of the oblique fibers of inter- arytenoid muscle in to the aryepiglottic fold.

- All intrinsic muscles of the larynx are supplied by recurren laryngeal nerve except Crico-thyroid m. which is supplied by external laryngeal nerve

Interior of Larynx

- The laryngeal cavity extends from the level of 3rd cervical vertebra to the lower border of the cricoid cartilage (c6) level. At the level of cricoid cartilage it becomes continuous with that of the trachea.
- Laryngeal cavity is divided by the presence of vestibular and vocal folds into:
  - Larynx above the vestibular fold is known as superior vestibule.
  - The ventricle or sinus of the larynx lies between the vestibular and vocal folds.
  - Below the vocal folds is subglottic space which extends to level of the lower border of the cricoid cartilage.
- False vocal cord (the ventricular bands): which are formed by the mucous membrane covering the ventricular ligament and the upper part of the external portion of the thyroarytenoid muscle.
- True vocal cords: Project further into than the false cords, and lie at a lower level. The covering epithelium is closely bound down to the underlying vocal ligament. The blood supply is poor, hence the pearly white appearance of the vocal cords.
• Histologically the vocal fold contains 5 layers:
  o **Layer 1** (*squamous epithelial lining*): It is very thin
  o **Layer 2** (*Superfical layer of the lamina propria = Reinke's space*): composed of loose fibers and matrix. This layer contains only minimal elastic and collagenous fibers and offers least resistance to vibration. The integrity of this layer is vital for proper phonatory function.
  o **Layer 3** (*Intermediate layer of lamina propria*): a higher concentration of elastic and collagenous fibres. Provides protection to the vocal folds from mechanical damage.
  o **Layer 4** (*Deep layer of lamina propria*): a dense collection of elastic and collagenous fibers. Along with the intermediate layer constitute the vocal ligament.
  o **Layer 5** (*vocalis muscle*): portion of thyro-arytenoid muscle.

**Vestibule**

• Lies between the laryngeal inlet and the edges of the false cords.
• Boundaries:
  o Posterior surface of epiglottis in front.
  o Interval between the arytenoid cartilages behind.
  o Inner surface of the aryepiglottic folds and upper surfaces of the false cords on each side.
• Laryngeal inlet: is bounded superiorly by free edge of epiglottis & on each side by the aryepiglottic folds.
• Posteriorly by the mucous membrane between the arytenoid cartilages.

**Mucous membranes of the larynx:**

• Most of the larynx is lined by pseudo stratified ciliated columnar 'respiratory' -type epithelium.
• The upper half of the posterior surface of the epiglottis, the upper part of the aryepiglottic fold, the posterior glottis and the vocal folds are covered with nonkeratinizing stratified squamous epithelium.
• Mucous glands are freely distributed throughout the mucous membranes and are particularly numerous on the posterior surface of the epiglottis and in the margins of the lower part of the aryepiglottic folds and in the saccules.
• The vocal folds do not possess any glands and the mucous membrane is lubricated by mucus from the glands within the saccules.
• The squamous epithelium of the vocal folds is there for prone to desiccation if these glands cease to function, for example after radiation.

**Ventricle of Larynx**

• Between the vestibular and vocal folds, overlie the ligaments of the same name.
• On each side the laryngeal ventricle opens into an elongated recess known as the laryngeal sinus.
• From the anterior part of the ventricle, a pouch called the saccule of the larynx ascends between the vestibular folds and the inner surface of the thyroid cartilage.
• The mucous membrane of saccule contains numerous mucous secreting glands. These secretions lubricates the vocal cord.

**Rima glottis:** is an elongated fissure present between the two vocal folds.

**Rima vestibuli:** The rima vestibuli is the triangular-shaped opening between the 2 adjacent vestibular folds.

**Pyriform recesses:**

• The pyriform recesses (pyriform sinuses) are present on either side of the anterolateral wall of the laryngopharynx. They are bounded medially by the aryepiglottic folds and laterally by the thyroid cartilage and thyrohyoid membrane. They are a common place for food to become trapped.
Spaces within the larynx:

- **Preepiglottic space:** Is a wedge shaped space lying in front of the epiglottis. It is bounded anteriorly by the thyrohyoid ligament and the hyoid bone. This space is continuous laterally with that of paraglottic space. Tumour may spread into this area through small perforations in the epiglottis or directly through, the hyoepiglottic ligament.
- **Paraglottic space:** is a potential space present on either side of glottis. It is bounded by the mucosa covering the lamina of thyroid cartilage laterally, the conus elasticus and quadrangular membranes medially and the anterior reflection of the pyriform fossa mucosa posteriorly.

Blood supply of the larynx: Is derived from the

- Laryngeal branches of the superior thyroid artery.
- Laryngeal branches of the inferior thyroid artery.
- The cricothyroid branch of the superior thyroid artery.
- The superior thyroid artery arises from the external carotid artery, and the inferior thyroid artery arises from the thyrocervical trunk.
- The veins leaving the larynx accompany the arteries:
  - The superior vessels drain to the internal jugular vein by way of the superior thyroid or facial veins.
  - The inferior vessels drain by way of inferior thyroid vein into the brachiocephalic veins.
  - Some venous drainage also occur through the middle thyroid vein into the internal jugular vein.

Lymphatic drainage

Separated by the vocal folds into an upper and lower group:

- The part of larynx above the vocal folds is drained by vessels accompanying the superior laryngeal vein,
- The zone below the vocal folds drains together with the inferior vein, into the lower part of the deep cervical chain often through the prelaryngeal and pretracheal nodes.
- The vocal folds are devoid of lymphatics, and it infact clearly forms the watershed zone between the upper and the lower group of lymphatics.

Nerve supply of the larynx

The larynx is supplied by branches of vagus nerve.

- Superior laryngeal nerve has two laryngeal branches:
  - **Internal branch.** Entirely sensory. It pierces the thyrohyoid membrane with the superior laryngeal artery and venn. It supplies the cavity of the larynx as far down the level of the vocal cords.
  - **External branch.** Travels down on the inferior constrictor muscle of the pharynx. It supplies the cricothyroid muscle and part of the ant. Subglottis.
- Recurrent laryngeal branch of the vagus nerve (CN X):
  - It has much longer course on the left side than on the right side.
  - On the lt. side it turns round the arch of aorta.
  - On the rt. Side it turns round the subclavian artery.
  - In the neck it lies between the trachea and oesophagus as it approach the larynx.
  - Its terminal part pass upwards, under cover of ala of the thyroid cartilage, immidiately behind the cricothyroid joint.
  - Divided In to:
    - Antero lateral (motor branch): which supply all the intrinsic ms. of the larynx except the cricothyroid m.
    - Posteromedial (sensory branch): supplies the cavity of larynx below level of vocal cords.
Physiology of Larynx

Functions of larynx:

1. Airway protection
2. Respiration
3. Swallowing
4. Coughing
5. Phonation

Airway protection

- The most important function of human larynx.
- A sphincter protecting the lower airway from secretions of oropharynx.
- Protects the airway from spillage of food during deglutition.
- Larynx has three protective mechanisms (from above downwards): Aryepiglottic fold, ventricular band and vocal cords.

Respiration

- Larynx is part of the upper airway passages
- Keeps the airway open during respiration.
- Contributes to the regulation of the acid-base balance in the blood by influencing CO₂ tension.

Swallowing

- During swallowing the sphincters of larynx stay contracted preventing aspiration of food into the air passage.

Coughing

- Coughing is the process by which material is expelled from the airway.
- It is preceded by rapid inspiration, followed by forceful closure of both the vocal and vestibular folds.
- Air pressure is then built up below the adducted folds.
- The diaphragm ascends spasmodically until the folds separate explosively and mucus or foreign material is expelled.

Phonation

- The larynx acts as a transducer during phonation converting the aerodynamic forces generated by the lungs, diaphragm, chest and abdominal muscles into acoustic energy.
- The requirements of normal phonation are as follows:
  1. Active respiratory support
  2. Adequate glottic closure
  3. Normal mucosal covering of the vocal cord
  4. Adequate control of vocal fold length and tension.
- The cycle of sound production involves glottic opening and closing at set frequencies determined by the subglottic air pressure.
- The function of vocal folds is to produce sound varying in intensity and pitch. This sound is then modified by various resonating chambers present above and below the larynx and are converted into words by the articulating action of the pharynx, tongue, palate, teeth and lips.