



Anatomy of Larynx A Review

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Abstract:

This article attempts to review anatomical aspects of larynx from a surgeon's perspective. Anatomically larynx is designed to protect the lower air way from oropharyngeal secretions. Vocalisation happens to be the beneficial offshoot of its protective function.

Introduction:

Larynx (voice box) is situated in the anterior portion of the neck above the trachea. Its location anterior to the inferior portion of the pharynx allows it to play an important role in deglutition. Primary function of larynx is protection of airway from food particles and secretion of oropharynx¹.

Embryology:

Development of larynx occur during the 4th week of intrauterine life, and is closely associated with the development of trachea². Development of larynx starts as a ventral groove in the pharynx known as the laryngotracheal groove. This groove deepens and its edges fuse to form a septum which separates the laryngotracheal tube from the pharynx and oesophagus.

This process of fusion starts caudally and extends cranially. This tube is lined with endoderm from which the epithelium of airway develops. The cranial end of this laryngotracheal tube forms the larynx and trachea, while the caudal end bifurcates to produce the two main bronchi. This is also the place from which the two lung buds develop. Since development of larynx, trachea and oesophagus are inter-linked, any congenital malformation of oesophagus is always associated with certain degree of malformation of larynx and trachea.

Developmentally larynx develops from the cranial part of laryngotracheal groove. It is bounded superiorly by the caudal part of hypobranchial eminence and laterally by ventral folds of 6th branchial arches. Epiglottis develops from hypobranchial eminence. Arytenoids develop on either side of laryngotracheal groove, and as they enlarge they become approximated with each other and to the caudal portion of hypobranchial eminence. This development converts the vertical slit of laryngeal cavity into a T shaped one.

The nerves supplying the 4th and 6th branchial arches also supply larynx (superior and recurrent laryngeal nerves).

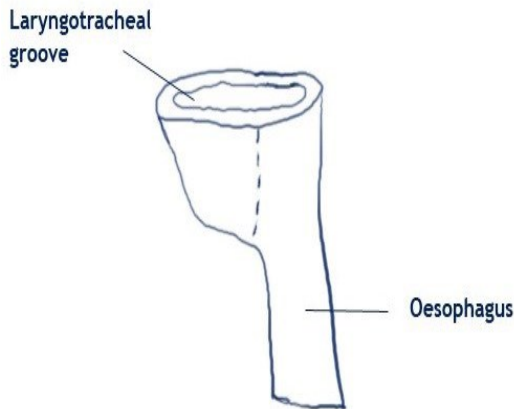


Figure showing development of larynx

Anatomical location:

Larynx is situated at the cranial end of trachea, extending between the 3rd and 6th cervical vertebrae. Larynx may be placed at a higher level in women and children. The size of the larynx is more or less similar in boys and girls till puberty. After puberty the antero posterior dimension doubles in males.

Larynx is situated between a large cavity i.e oral cavity and the smaller trachea. This unique location makes lower airway vulnerable to aspiration in humans. Larynx has to play a definite protective role in protecting lower air way from the wider crucible (oropharynx).

Development of laryngeal cartilages

Name of the cartilage	Developed from
Thyroid cartilage	Ventral ends of 4 th arch cartilage
Arytenoids	6 th arch cartilage
Corniculate	6 th arch cartilage
Epiglottis	Hypobranchial eminence
Cricoid & tracheal cartilages	6 th arch cartilage

Dimensions of Larynx³

Sexes	Length	Transverse	Antero posterior
Male	44 mm	43 mm	36 mm
Female	36 mm	41 mm	26 mm

Larynx of infants:

Starts high up under the tongue and with development and slowly descends to the adult position. It is absolutely and relatively smaller than that of the larynx of the adult.



The lumen is hence disproportionately narrower in infants. It is more or less shaped like a funnel, the narrowest portion being the subglottic region at the junction of the trachea ⁴. The lining mucosa is also lax. Even a slight swelling of the lax mucosa in this area may produce a serious obstruction to breathing. The laryngeal cartilages in infants are suppler, and hence collapses easily during forced inspiratory efforts adding to the crisis. However a number of studies reveal larynx in infants being tubular with glottis area being the narrowest portion ⁵.

Laryngeal framework:

The framework of the larynx is formed by cartilages. These cartilages are linked by ligaments and membranes. They move in relation to one another by the action of two groups of muscles i.e. Intrinsic and Extrinsic muscles. The mucosal lining of the larynx is continuous above with that of pharynx and below with that of trachea.

Cartilages of larynx:

Thyroid cartilage:

This is the largest of the 9 cartilages that make up the laryngeal skeleton. This cartilage is more or less shaped like a shield. It is the largest of the laryngeal cartilages. It has two laminae which meet in the midline inferiorly.

Thyroid notch is formed by incomplete fusion of two thyroid cartilage laminae superiorly. 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. In infants there is a small strip of cartilage between the two laminae of the thyroid cartilage known as the intrathyroid cartilage. The laminae of the thyroid cartilage diverge posteriorly. The posterior border of the two laminae are prolonged as two slender processes known as the superior and inferior cornua. The superior cornua is long and narrow, curving upwards, backwards and medially ending in a conical projection. Lateral thyrohyoid ligament gets attached here. The inferior cornu is shorter and thicker than the superior cornua. It curves downwards and medially. At its lower end there is a small facet for articulation with the cricoid cartilage. One important landmark to note is the junction between the superior cornu and the thyroid ala, where a small cartilaginous projection (superior tubercle) is present. Just 1 cm below this tubercle is the point of entry of superior laryngeal artery and nerve into the larynx piercing the thyrohyoid membrane.

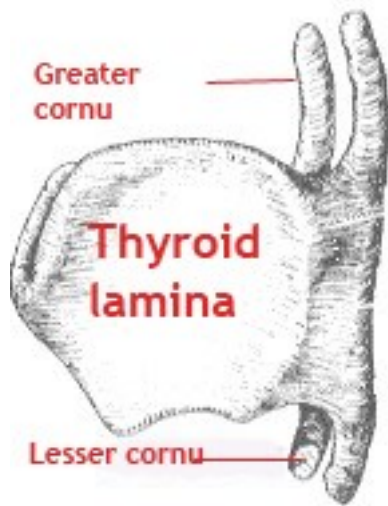


Figure showing thyroid cartilage

On the outer surface of each lamina of the thyroid cartilage is an oblique line extending from the superior thyroid tubercle to the inferior thyroid tubercle. The superior thyroid tubercle is situated in front of the root of the superior horn, and the inferior tubercle is situated on the lower border of the thyroid lamina. The oblique line gives attachment to the following muscles:

1. Thyrohyoid muscle
2. Sternohyoid muscle
3. Inferior constrictor muscle

The inner portion of the lamina is covered by loosely attached mucous membrane.

Ligaments attached to the thyroid cartilage:
Thyroepiglottic ligament: is a slender elastic ligament connecting the stem of the epiglottis to the angle of the thyroid cartilage just below the thyroid notch.

Vestibular ligament: Also known as the false vocal cord. This is a narrow band of fibrous tissue attached to the angle of the thyroid cartilage just below the attachment of the root of the epiglottis. This ligament raises a thick fold of mucous membrane known as the vestibular fold. This ligament constitutes the upper border of the ventricle of the larynx.

Vocal ligament: Also known as the true vocal cord is responsible for the generation of voice. This is attached just below the level of vestibular ligament. This ligament raises a mucosal fold known as vocal fold. The vocal ligament gets attached to the angle formed by the thyroid laminae just under the vestibular fold. In fact this ligament has been considered to be the thickened superior portion of the cricothyroid ligament. The vocal ligament gets arises from the vocal process of the arytenoid cartilage and gets attached to the thyroid angle.



Histology of the vocal cord: The study of histology of vocal cord is vital in understanding the pathophysiology of various voice disorders. The free edge of the vocal fold is highly adapted for phonation. The vocal fold is covered with squamous epithelium unlike the respiratory tract which is covered by ciliated columnar epithelium. The arrangement of connective tissue under the vocal fold makes it easy for the vocal fold to vibrate freely over the vocalis muscle without any restriction.

Histologically the vocal fold is said to contain 5 layers:

Layer 1: is the squamous epithelial lining. It is very thin and helps to hold the shape of the vocal fold. This layer does not contain any mucous glands, and hence the mucoid secretions lining the cord must travel from the glands located anteriorly, superiorly and posteriorly to the edges of the vocal fold.

Layer 2: This is also otherwise known as the superficial layer of the lamina propria. It is composed of loose fibers and matrix. In clinical parlance it is also referred to as the Reinke's space. 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.

Layer 3: Is the intermediate layer of lamina propria. It contains a higher concentration of elastic and collagenous fibers when compared to layer ². This layer is thickened at the anterior and posterior ends of the vocal folds.

These thickened regions are known as anterior and posterior macula flava. These structures provide protection to the vocal folds from mechanical damage.

Layer 4: Is the deep layer of lamina propria. It contains a dense collection of elastic and collagenous fibers. This layer along with the intermediate layer constitute the vocal ligament. The vocal ligament is considered to be the upper most portion of conus elasticus (cricothyroid ligament). Some of the collagenous fibers present here gets inserted into the vocalis muscle. The intermediate and the deep layers of lamina propria cannot be easily separated.

Layer 5: Is formed by the vocalis muscle. The fibers of this muscle run parallel to the direction of the vocal fold. Vocalis muscle is in fact a portion of thyro arytenoid muscle. At the anterior most portion of the vocal fold a mass of collagenous tissue is present. This is known as the anterior commissure tendon or Broyle's ligament. This ligament gets attached to the inner thyroid perichondrium. This tendon serves as an important barrier delaying spread of malignant tumors from glottis to subglottis ⁶.

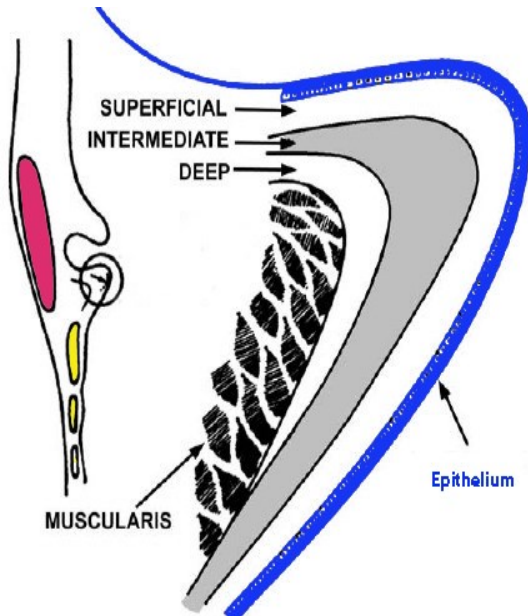


Figure showing ultrastructure of vocal fold

The vocal fold epidermis is secured to the superficial layer of lamina propria through a basement membrane. This basement membrane zone is a collection of protein and non-protein materials, which help the basal cells of the epidermis to secure themselves to the lamina propria. This unique anchoring system allows the epidermal cells to adhere to the gelatinous lamina propria. This anchoring system is very vital for voice production. The number of these anchoring fibers are genetically determined.

Individuals having fewer of these anchoring fibers are more prone for vocal nodule formation.

The lamina propria contains numerous cellular elements. They are:

1. Macrophages
2. Fibroblasts
3. Myofibroblasts

Among these cells the myofibroblasts are fibroblasts differentiated for reparative purposes. These myofibroblasts play a vital role in repairing trivial vocal cord injuries,⁷ provided adequate time and rest is given to the vocal fold. This minimal repair can take place within a couple of days. Deeper injuries to the cord are difficult to repair and may cause irreparable damage to voice.

Cricoid cartilage: Is the only complete cartilage in the whole of the respiratory pathway. It is shaped like a signet ring. It is composed of a deep broad quadrilateral lamina posteriorly and a narrow arch anteriorly. At the junction of the arch and lamina of the cartilage an articular facet is present where the inferior cornua of the thyroid cartilage articulates. The shoulder of the lamina of the cricoid cartilage is sloping in nature and has articular facets for arytenoid cartilage articulation. These joints in the cricoid cartilage are synovial in nature. The cricoid cartilage articulates with the thyroid cartilage about an axis passing transversely through these joints.

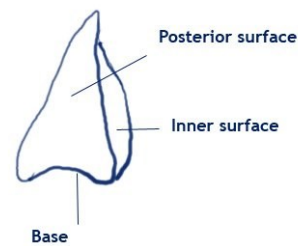
A vertical ridge is present in the midline of the lamina of the cricoid cartilage. The longitudinal muscle of the oesophagus gets attached in this ridge. On each side of this ridge concavities are present from which the posterior cricoarytenoid muscles originate.

Arytenoid cartilages:

These are small paired cartilages placed close together on the upper and lateral borders of the cricoid lamina. These cartilages are pyramidal shaped. It 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. To these muscular process are attached the following muscles: Posterior crico arytenoid and lateral cricoarytenoid muscles. Between the vocal and muscular processes is the antero lateral surface of the arytenoid cartilage. This surface is irregular and is divided into two fossae by a crest. The upper triangular fossa gives attachment to the vestibular ligament and the lower to the vocalis muscle and lateral cricoarytenoid muscles.

The apex of this cartilage curves backwards and articulates with corniculate cartilages. Aryepiglottic folds are attached to these cartilages. The medial surfaces of arytenoid cartilage are covered with mucous membrane and form the lateral boundary of the intercartilagenous part of the rimma glottides. The posterior surface of arytenoid cartilage is covered with transverse arytenoid muscle.

Arytenoid cartilage



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Figure showing arytenoid cartilage

Corniculate and cuneiform cartilages: The corniculate cartilages are small conical nodules of fibroelastic cartilage articulating with the apices of arytenoid cartilage. The cuneiform cartilages are two small elongated fibroelastic cartilage one in each margin of the aryepiglottic fold.

Epiglottis: is a leaf shaped fibroelastic cartilage which projects upwards behind the tongue and the body of the hyoid bone. Its narrow stalk is attached by thyroepiglottic ligament to the angle between the thyroid laminae, below the thyroid notch. Its upper part is broad and is directed upwards and backwards. Its superior margin is free. The sides of the epiglottis is attached to the arytenoid cartilages by aryepiglottic folds.



The anterior surface of the epiglottis is free and is covered with mucous membrane which is reflected on to the pharyngeal part of the tongue and on to the lateral wall of pharynx, forming 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.

Ligaments of larynx: Can be divided into Extrinsic and Intrinsic ligaments.

Extrinsic ligaments: are ligaments that connect the laryngeal cartilages to the hyoid bone above and trachea below.

Thyrohyoid membrane: stretches between the upper border of the thyroid and the upper border and posterior surfaces of the body and greater cornua of the hyoid bone. This membrane is composed of fibroelastic tissue which is strengthened anteriorly by condensation of fibrous tissue known as the median thyrohyoid ligament. The posterior margin is also thickened to form the lateral thyrohyoid ligament which connects the tips of the superior cornua of the thyroid cartilage to the posterior ends of greater cornua of the hyoid bone.

Cricotracheal ligament: Unites the lower border of the cricoid cartilage with the first tracheal ring.

Hyoepiglottic ligament: connects the epiglottis to the back of the body of the hyoid bone.

Intrinsic ligaments: are ligaments that connect the laryngeal cartilages. They also strengthen the capsule of intercartilagenous joints. They also form a broad sheet of fibroelastic tissue which lie beneath the mucous membrane of the larynx thus creating an internal framework.

The fibroelastic membrane is divided into an upper and lower part by the presence of laryngeal ventricle. The upper membrane is also known as the quadrilateral membrane. It extends between the border of epiglottis and the arytenoid cartilage. Its upper margin forms a framework for the aryepiglottic fold, which forms the laryngeal inlet, 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, and above it is stretched between the midpoint of the laryngeal prominence of thyroid cartilage anteriorly and the vocal process of the arytenoid behind. The free upper border of this membrane forms the vocal cord.

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. The whole laryngeal cavity is divided by the presence of vestibular and vocal folds into three compartments.

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 the subglottic space which extends up to the level of the lower border of the cricoid cartilage. The fissure present between the vestibular folds is known as the rimma vestibuli, while the fissure between the vocal folds is known as the rimma glottis.

Laryngeal inlet: is bounded superiorly by the free edge of epiglottis and on each side by the aryepiglottic folds. Posteriorly, the inlet is bounded by the mucous membrane in-between the two arytenoid cartilages.

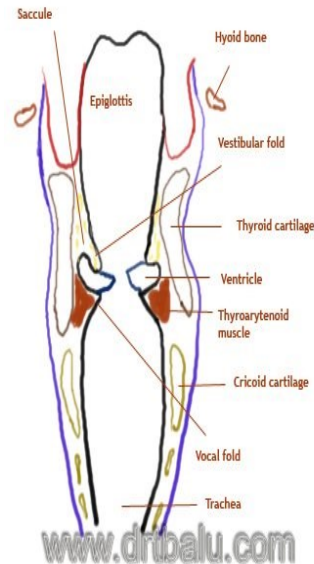


Figure showing interior of larynx

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. The hyoepiglottic ligament connects the epiglottis to the hyoid bone. This space is continuous laterally with that of paraglottic space.

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.

Ventricle: of the larynx lie between the vestibular and vocal folds. These 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 sacculle of the larynx ascends between the vestibular folds and the inner surface of the thyroid cartilage. It may extend as far as the upper border of the thyroid cartilage. The lining mucous membrane of sacculle contains numerous mucous secreting glands. These secretions find its way to line the vocal cord thereby lubricating it. Hence the sacculle is termed as the oil can of larynx.

Rima glottis: is an elongated fissure present between the two vocal folds. It is limited behind by the mucous membrane between the arytenoids. The region between the vocal folds accounts for three-fifths of the length of the aperture and is termed as the intermembranous part. The remainder of the rima glottis lie between the vocal processes of arytenoid cartilage. This portion is hence termed as the intercartilagenous part.

Muscles of larynx: can be divided into intrinsic and extrinsic muscles. The extrinsic muscles of the larynx connect the laryngeal cartilages to the hyoid bone above and trachea below. The intrinsic muscles of the larynx interconnect the laryngeal cartilages and help in their mobility.

Intrinsic muscles of larynx may be divided into those that open and close the glottis, (lateral and posterior cricoarytenoid muscles, transverse and oblique arytenoids), those that control the tension of vocal ligaments (thyroarytenoids, vocalis and cricothyroids), those that alter the shape of the inlet of the larynx (aryepiglotticus and the thyroepiglotticus). Except transverse arytenoid, all these muscles are paired.

Lateral cricoarytenoid muscle: arises from the superior border of the lateral part of the arch of the cricoid cartilage and is inserted into the front of the muscular process of the arytenoid. It adducts the vocal ligaments by rotating the arytenoids medially.

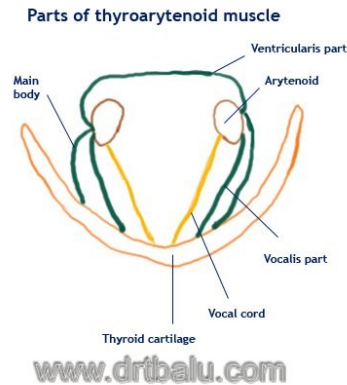


Figure showing parts of thyroarytenoid muscle

Posterior cricoarytenoid muscle: is the only muscle that opens the glottis. It arises from the lower and medial surface of the cricoid lamina and fans out to be inserted into the back of the muscular process of the arytenoid cartilage. Its upper fibers are almost horizontal, while its lateral fibers are almost vertical. The horizontal action rotates the arytenoids and moves the muscular process towards each other, separating the vocal processes and thus abducts the vocal cords.

Interarytenoid muscles: comprise paired oblique arytenoid muscles and unpaired transverse arytenoid muscle. They adduct the vocal folds.

Extrinsic muscles of larynx: are sternothyroid, thyrohyoid and inferior constrictor of the pharynx.



Blood supply:

Is derived from the laryngeal branches of the superior and inferior thyroid arteries and 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:

The lymphatics of the larynx are separated by the vocal folds into an upper and lower group. The part of the larynx above the vocal folds is drained by vessels accompanying the superior laryngeal vein, whereas 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 in fact clearly forms the watershed zone between the upper and the lower group of lymphatics.

Nerve supply:

The larynx is supplied by branches of vagus nerve i.e. superior and recurrent laryngeal nerves.

Superior laryngeal nerve: arises from the inferior vagal ganglion. It also receives a branch from the superior cervical sympathetic ganglion. Descending lateral to the pharynx, behind the internal carotid and at the level of greater horn of hyoid bone, divides into a small external laryngeal branch and a larger internal laryngeal nerve branch. The external laryngeal nerve provides motor supply to the cricothyroid muscle, while the internal laryngeal nerve pierces the thyrohyoid membrane above the entrance of the superior laryngeal artery and divides into sensori and secretomotor branches.



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