Anatomy of the Pharynx and Oesophagus

EMBRYOLOGY

- Cephalocaudal and lateral folding result in the formation of an endodermally lined primitive gut.
- In its cephalic part this forms a blind ending tube, the foregut, which is separated from the ectodermally lined stomatodaeum by the Buccopharyngeal membrane.
- This ruptures and the stomatodaeum becomes continuous with the foregut.

EMBRYOLOGY OF PHARYNX AND PHARYNGEAL ARCHES

- Pharyngeal arches develop at 5th week of IUL
- Three layered – Core of mesoderm, externally ectoderm and internally endoderm.
- Separated externally by pharyngeal clefts and inside by depressions corresponding to clefts called pharyngeal pouches.
- 4 pairs of pharyngeal pouches (5th considered part of 4th).
- So there are 4 grooves / clefts, 4 pouches (5th part of 4th), 6 Arches.
- Each portion has its own importance and development
Each pouch has a **VENTRAL** and a **DORSAL** section.

**DERIVATIVES**

<table>
<thead>
<tr>
<th>Pouch</th>
<th>Dorsal section</th>
<th>Ventral section</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>Middle ear and Eustachian tube (with 2nd)</td>
<td>Obliterated</td>
</tr>
<tr>
<td>2nd</td>
<td>Dorsal pharyngeal wall – nasopharynx and adenoid</td>
<td>Tonsil</td>
</tr>
<tr>
<td>3rd</td>
<td>Parathyroid – inferior</td>
<td>Thymus</td>
</tr>
<tr>
<td>4th</td>
<td>Parathyroid – superior</td>
<td>Ultimobranchial body – C cells of thyroid</td>
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</tbody>
</table>

**FIRST POUCH**

- **DORSAL PORTION**:
  - The endoderm lines the future auditory tube (Pharyngotympanic Eustachian tube), middle ear, mastoid antrum, and **inner layer of the tympanic membrane**.
- **VENTRAL** – Obliterated

**SECOND POUCH**

- **DORSAL PORTION** – Contributes the middle ear, Nasopharynx, Adenoids
- **VENTRAL PORTION** – Palatine tonsils, supplied by the facial nerve.

**THIRD POUCH**

- **DORSAL** – Inferior parathyroid glands
- **VENTRAL** – Cytoreticular cells of the thymus

**FOURTH POUCH**

- **DORSAL** – Superior parathyroid glands
- **VENTRAL** – Ultimobranchial body which forms the parafollicular C-Cells of the thyroid gland. Musculature and cartilage of larynx (along with the sixth pharyngeal arch).
- Fifth pouch is a Rudimentary structure, becomes part of the fourth pouch contributing to thyroid C-cells.

**PHARYNGEAL CLEFT DERIVATIVES**

- The first cleft invaginates to form External Acoustic meatus.
The mesoderm of the second arch actively proliferates and moves downwards to overlap the third and fourth arches and clefts fusing with the epicardial ridge in the lower neck.

The second, third and fourth clefts lose contact with the outside and form a temporary cavity lined with ectoderm, the cervical sinus. This usually disappears completely but may persist as a branchial cleft cyst.

Occasionally, the mesoderm between the second pharyngeal cleft and pouch will break down leaving a sinus with an external opening on the skin of the neck and an internal opening in the tonsillar fossa i.e. brachial fistula.

**DERIVATIVES OF PHARYNGEAL ARCHES**

<table>
<thead>
<tr>
<th>Arch</th>
<th>Skeletal and cartilage components</th>
<th>Muscles</th>
<th>Post-trematic nerve</th>
<th>Pretrematic nerve</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>Dorsal-maxillary process</td>
<td>Muscles of mastication</td>
<td>Mandibular division of trigeminal (V3)</td>
<td>Chorda tympani</td>
</tr>
<tr>
<td></td>
<td>Ventral-Meckel’s cartilage</td>
<td>Anterior belly of digastric</td>
<td></td>
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<tr>
<td></td>
<td>Incus</td>
<td>Mylohyoid</td>
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<tr>
<td></td>
<td>Malleus</td>
<td>Tensor tympani</td>
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<tr>
<td></td>
<td>Sphenomandibular ligament</td>
<td>Tensor palati</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd</td>
<td>Stapes</td>
<td>Stapedius</td>
<td>Facial (VII)</td>
<td>Tympamic branch of IX (Jacobson’s nerve)</td>
</tr>
<tr>
<td></td>
<td>Styloid</td>
<td>Stylohyoid</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Stylohyoid ligament</td>
<td>Posterior belly of digastric</td>
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<tr>
<td></td>
<td>Lesser horn and upper part of hyoid</td>
<td>Auricular muscles</td>
<td></td>
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<tr>
<td></td>
<td>Stapedial process</td>
<td>Muscles of facial expression</td>
<td></td>
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<tr>
<td></td>
<td>Lower part and greater horn of hyoid</td>
<td>Stylpharyngeus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3rd</td>
<td>Thyroid</td>
<td>Cricothyroid</td>
<td>Glossopharyngeal (IX)</td>
<td>Not well defined in man</td>
</tr>
<tr>
<td>4th and 6th</td>
<td>Thyroid, Cricoid, Arytenoids, Corniculate, Cuneiform</td>
<td>Cricothyroid, Levator palati</td>
<td>Vagus (X) and accessory (IX) nerves</td>
<td></td>
</tr>
</tbody>
</table>

**Pneumonic to remember the arch derivatives:**

**M**ake Some Important **S**Htuff

**M** – for 1st arch – Maxillary artery, Mandibular Nerve, Masticatory muscles, Meckels cartilage, Mandible, Maxilla, Malleus, incus, Mylohyoid, anterior belly of diagastric, tensor tympani, tensor palate and sphenomandibular ligament.

**S** – Seventh nerve, Stapedial artery, Stapes, Styloid, Stylohyoid ligament,
Stylohyoid muscle, Stapedius, Smile i.e., muscles of facial expression, posterior belly of diagastric, auricular muscles, upper part and lower horn of hyoid.

I – Internal carotid artery, Inferior parathyroid by 3rd pouch, lower part and greater horn of hyoid, glossoPHARYNGEAL nerve so StyloPHARYNGEUS muscle

So 2nd arch hyoid derivative is Upper body and lesser horn.

Rotate 3 and it looks like lower body. So Lower body and greater horn by 3rd arch.

SH stands for Shared development.

“4th gets the best, 6th gets the rest”

4th ARCH – Xth nerve (Superior Laryngeal Nerve), Cricothyroid muscle, Thyroid cartilage, Arch of aorta, right subclavian artery.

6th ARCH – Xth nerve (Recurrent laryngeal nerve), REST of Laryngeal musculature, rest all laryngeal cartilages, pulmonary artery and ductus arteriosus.

EMBRYOLOGY OF THE OESOPHAGUS

Oesophagus develops from foregut below the primitive pharynx.

At the upper end of the foregut the tracheobronchial diverticulum appears on the ventral wall around the fourth week.

This becomes separated from the developing oesophagus by the Tracheobronchial septum, which grows in from either side. The trachea bronchial diverticulum goes on to form the larynx, trachea and bronchi.

The primitive oesophagus is at first a short tube extending from the trachea bronchial diverticulum to the fusiform dilatation of the foregut, which is to
become the stomach. It extends down as the heart and lungs descend.

**ANATOMY OF THE PHARYNX**

Funnel shaped muscular tube extending from Skull base to C6 / lower border of cricoid cartilage which is continuous with the Oesophagus.

**NASOPHARYNX**

- Extends vertically from skull base to junction of hard and soft palate.
- **Posterosuperior Wall** – Anteroinferior surface of body of Sphenoid and basilar part of occipital bone, the ‘basiphenoid’ and contains the adenoids.
- **Posterior wall** – Pharyngobasilar facial covering C1 (Atlas) extending from skull base to junction of hard and soft palate and opens in oropharynx.
- **Lateral wall** – Cartilagenous eustachian tube opens into the lateral wall of the nasopharynx approximately 1 cm behind the inferior turbinate. It forms an elevation shaped like a comma, with a shorter anterior limb and longer posterior limb (*Torus tubaris* / tubal tonsil / *Gerlach’s tonsil*). Behind and above this is the **pharyngeal recess (fossa of Rosenmuller)**, which passes laterally above the edge of the superior constrictor formed by mucosal reflection over longus colli muscle.
- From **posterior edge of eustachian tubal opening** – Salpingopharyngeal fold due to underlying Salpingopharyngeus muscle.
- From **anterior edge of eustachian tubal opening** – Less well defined fold till upper surface of soft palate indicates levator palate muscle.

**OROPHARYNX**

- Oral cavity demarcation from oropharynx is → Junction of hard and soft palate superiorly, palatoglossus laterally, Circumvallate papillae inferiorly
- Extends **Vertically** from junction of hard and soft palate to floor of valleculae.
- **Anteriorly** from anterior pillar (palatoglossus), then posterior pillar i.e. Palatopharyngeus, (passes downwards and backwards from the lower border of soft palate to the side wall of the pharynx where it fades away).
- **Posterior wall** – Constrictor muscles and overlying mucous membrane.
- **Superior wall** – Inferior surface of soft palate and uvula
- Below the oropharyngeal isthmus, the anterior wall is formed by the tongue base, behind the vallate papillae, and below this are the valleculae. These are separated in the midline by the median Glossoepiglottic fold passing from the base of tongue to the lingual surface of the epiglottis. Laterally, each valleculae is bounded by the lateral Glossoepiglottic fold.
HYPOPHARYNX

- Behind and to the sides of inner part of larynx.
- Posteriorly – level of floor of valleculae to cricoarytenoid joint formed by constrictors and overlying mucous membrane.
- Below this i.e. from Cricoarytenoid joint till the inferior border of cricoid cartilage is called **Post cricoid region.** (bounded Anteriorly by the posterior plate of cricoid cartilage and encircled by the cricopharyngeus muscle which forms upper esophageal sphincter)
- Superiorly – the anterior wall of the hypopharynx is continuous with the laryngeal inlet.
- This is bounded anteriorly and superiorly by the upper part of the epiglottis, posteriorly by the elevations of the arytenoid cartilages and laterally by the aryepiglottic folds
- To each side of the larynx lie the **piriform fossa.**
- **PIRIFORM FOSSA** – These are bounded laterally by the thyroid cartilage and medially by the lateral surface of the aryepiglottic fold, the arytenoid and cricoid cartilages. They extend from the lateral Glossoepiglottic fold to the upper end of the oesophagus.

THE SOFT PALATE

STRUCTURE OF THE SOFT PALATE

- The soft palate is formed by the expanded tendons of the tensor palati muscles which join in a median raphe called the palatine aponeurosis,
- This aponeurosis is attached to the posterior edge of the hard palate and to its inferior surface behind the palatine crest.
- Near the midline it splits to enclose the uvular muscle and all the other muscles of the soft palate are attached to it.
- Oropharyngeal isthmus bounded superiorly by the soft palate, laterally by palatopharyngeal fold and palatoglossal folds (arising from base of uvula), and inferiorly base of tongue.
- The soft palate (mainly inferior aspect) contains numerous mucous glands and lymphoid tissue.

MUSCLES OF SOFT PALATE

TENSOR VELI PALATINI MUSCLE

- The tensor veli palatini is found anterior-lateral to the levator veli palatini muscle.
- Remember - All the muscles of the soft palate, except the tensor palati, are supplied by the Pharyngeal Plexus (Sensory supply via Pharyngeal branch of Glossopharyngeal nerve (IX); Motor via cranial root of accessory(XI); mixed via vagus(X)) with an additional supply from the facial nerve (greater petrosal nerve). Sympathetic fibres from Superior Cervical ganglion.
Sensation to the palate is provided by the maxillary division of the trigeminal nerve, through its greater and lesser palatine branches, and the pharyngeal branches of the glossopharyngeal nerve.

Glossopharyngeal nerve is sensory to most of oro and laryngopharynx except Stylopharyngeus for which it has motor supply.

Innervation – V3 (Mandibular division of trigeminal nerve)

Function – Elevation of soft palate (assisting Levator Veli Palatini) & Opening of Eustachian tube during yawning or swallowing.

LEVATOR VELI PALATINI

PALATOGLOSSUS

Innervation – Pharyngeal plexus

Function – Depression of soft palate & elevation of against the soft palate i.e. closure of Oropharyngeal isthmus

PALATOPHARYNGEUS

Innervation – Pharyngeal plexus

Function – Elevation of larynx and shortening the pharynx by pulling the pharyngeal wall upwards, forwards and medially.

UVULAR MUSCLES

Innervation – Pharyngeal plexus

Function – Shortens the uvula and bulks up the dorsal surface of soft palate.

VASCULATURE OF THE SOFT PALATE

Ascending Palatine branch of Facial artery

Palatine Branch of Ascending Pharyngeal artery (Main supply)

Descending Palatine branch (via lesser palatine artery) of Maxillary artery.

VENOUS DRAINAGE is to the pterygoid plexus and then through the facial veins.

LYMPHATICS drain to the upper deep cervical nodes and to the retropharyngeal nodes.

THE PHARYNGEAL WALL

4 layered – M(EL)PMB i.e. Mucosa (Innermost having epithelial layer and lamina propria), Pharyngobasilar fascia, Muscular layer and Buccopharyngeal fascia.

MUCOUS MEMBRANE
Lined by pseudostratified ciliated columnar epithelium with goblet cells.

Pierced by the ducts of minor salivary glands that lie in the submucosal plane.

Oropharynx & Hypo pharynx – nonkeratinizing stratified squamous epithelium.

Immediately beneath the epithelium there is a connective tissue *lamina propria* that contains a large amount of elastic tissue, which takes the place of the *muscularis mucosa* found in the esophagus.

**PHARYNGOBASELAR FASCIA**

- Fibrous, attached to Occipital bone (basilar part) and Temporal Bone (petrous part).
- Bridges the gap between the superior border of the superior constrictor and the base of the skull. In this region it is firmly united to the buccopharyngeal fascia forming a single layer.
- The fibrous layer diminishes in thickness as it descends.
- It is strengthened posteriorly by a strong fibrous band which is attached above to the pharyngeal tubercle on the undersurface of the basilar portion of the occipital bone and passes down as a median raphe, which gives attachment to the constrictors.

**MUSCLE LAYER**

- Inner Paired Longitudinal – Stylopharyngeus, Palatopharyngeus and Salpingopharyngeus.
- Outer Paired Circular – Superior, Middle and Inferior constrictors.
- Each of the constrictors is shaped like a fan, arising from the lateral wall of the pharynx and sweeping around to be inserted into the median raphe posteriorly.
- The muscles overlap each other from below upwards.
- During deglutition the longitudinal muscles elevate the larynx and shorten the pharynx while the constrictors contract in a coordinated way to propel the bolus through the oropharynx into the oesophagus.
- The inferior constrictor is made up of two muscle groups:
  - Thyropharyngeus – Superiorly
  - Cricopharyngeus – Inferiorly
- The fibres of the Cricopharyngeus are continuous with the circular fibres of the upper oesophagus.
- Posteriorly, there is a small triangular interval between the upper end of the Cricopharyngeus and the lower fibres of the Thyropharyngeus, so-called 'Killian's dehiscence'.

**BUCCOPHARYNGEAL FASCIA**

- The Buccopharyngeal fascia is a thin fibrous coat of areolar tissue covering the pharyngeal constrictor muscles.
- It contains the pharyngeal plexus of nerves and veins.
Posteriorly, it is loosely attached to the prevertebral facia and laterally to the styloid process, the muscles arising from the styloid and to the carotid sheath.

STRUCTURES RELATED TO THE PHARYNX

Superior Constrictor – Lateral relations –
- Nerve – V3 nerve (lingual and inferior alveolar branches)
- Artery – Ascending pharyngeal artery, Ascending palatine branch of facial artery
- Ligament – Stylohyoid ligament
- Muscle – Styloglossus and Stylopharyngeus muscles and more laterally medial pterygoid muscle.

Middle Constrictor – Lateral Relations
- Artery – Lingual artery
- Nerve – Hypoglossal
- Muscle – Hypoglossus, Posterior belly of diagastric.

Inferior Constrictor – Lateral Relations
- Nerve – External laryngeal nerve
- Gland – Thyroid
- Muscles – Sternothyroid, Sternohyoid and omohyoid muscles.

NERVE SUPPLY OF PHARYNX
- External laryngeal nerve, receives parasympathetic vagal fibres from the recurrent laryngeal nerve (relaxation) and postganglionic sympathetic fibres from the superior cervical ganglion (contraction)
- The tongue in front of the valleculae and the valleculae themselves are supplied by the internal laryngeal nerve, a branch of the superior laryngeal nerve of the Vagus.

PHARYNGEAL VASCULATURE
- **Ascending pharyngeal artery** arises from the medial aspect of the external carotid artery just above its origin.
- The pharyngeal plexus drains to the internal jugular vein and anterior facial veins, it also communicates with the pterygoid plexus.
- Lymphatics from the upper part of the pharynx drain first to the retropharyngeal lymph nodes and then join the oropharynx in draining to the upper deep cervical nodes.
- The hypopharynx drains to the inferior deep cervical group and paratracheal nodes.
LYMPHOID TISSUE OF THE PHARYNX

- GALT – Gut associated Lymphoid Tissue i.e. an unencapsulated lymphoid tissue in the lamina propria of upper aero digestive tract
- The nasopharyngeal, tubal, palatine and lingual tonsils form a ring of GALT at the level of the oropharyngeal and nasopharyngeal isthmus, known as Waldeyer's ring.

THE PALATINE TONSIL

- Located between the palatoglossus and palatopharyngeal arches
- Separated from tongue via a sulcus names Tonsillolingual sulcus.
- Medial surface of the tonsil is characterized by numerous tonsillar crypts, which may penetrate nearly the whole thickness of the tonsil.
- The deep surface of the tonsil is covered by a fibrous capsule, which is separated from the wall of the oropharynx by loose areolar tissue.
- Laterally, the floor of the tonsillar fossa is formed by the pharyngobasilar fascia overlying in its upper part the superior constrictor and below the Styloglossus muscle passing forward into the tongue.
- The glossopharyngeal nerve and stylohyoid ligament pass obliquely downwards and forwards beneath the lower edge of the superior constrictor in the lower part of the tonsillar fossa.

ANATOMY OF THE OESOPHAGUS

- Extent – Lower border of cricoid cartilage at C6 vertebral level to the cardiac orifice of stomach i.e. T11.
- 25 cm in adults with diameter varying from 20 to 30 mm (stretching to allow passage of food bolus)
- In its course, it follows the curvature of the spine posteriorly and deviates to the left initially until it returns to the midline in the posterior mediastinum.
- A second bend to the left occurs as the oesophagus crosses the descending thoracic aorta to pierce the diaphragm.
- The oesophagus is the narrowest region in the digestive tract.
- It has three constrictions: at 15 cm from the incisors the Cricopharyngeal sphincter, at 23 cm it is crossed by the aortic arch and left main bronchus and at 40 cm it pierces the diaphragm.

OESOPHAGEAL WALL

- Four layers from inside out – Mucous membrane, Submucosa, Muscular coat and an outer Fibrous layer.
- Lining – Nonkeratinized stratified squamous epithelium continuous with that of pharynx.
Beneath mucosa is loose connective tissue of lamina propria containing elastic fibres and GALT.

The submucosa loosely connects the mucous membrane and the muscular coat. It contains blood vessels, lymphatics, and Meissner's plexus of postganglionic parasympathetic nerve fibres and minor mucous glands, which lubricate the oesophagus.

The muscularis mucosa lies deep to this, becoming thicker as it descends.

The muscular coat has an outer longitudinal layer which is complete apart from a small dehiscence at the upper end where the fibres diverge from the midline posteriorly to form two longitudinal bundles which come around anteriorly and attach to the posterior lamina of the cricoid cartilage.

The inner circular layer is continuous superiorly with the fibres of the Cricopharyngeus and inferiorly with the oblique fibres of the stomach.

The muscles of the upper third of the oesophagus are striated, while in the lower third they are smooth with a transitional zone in the middle third.

The fibres of Cricopharyngeus make up the upper esophageal sphincter while at the lower end there is no anatomical sphincter.

It is thought that a number of factors contribute to closure of the lower oesophagus including:

- Intrinsic muscle activity
- Encircling fibres of the right crus of the diaphragm
- Oblique fibres of the stomach
- Thoracoabdominal pressure gradient
- Angle of the oesophagogastric junction.

Nerve supply to the oesophagus

- Upper 1/3rd (Striated muscles) – Recurrent Laryngeal Nerve

The smooth muscle is supplied by parasympathetic fibres from the esophageal branches of the Vagus and recurrent laryngeal nerves. These fibres synapse in the ganglia of the submucosa (Meissner’s plexus) and myenteric (Auer Bach’s) plexus, between the longitudinal and circular muscle layers.

The oesophageal mucosa is sensitive to heat and cold but insensitive to touch.

**VASCULATURE OF THE OESOPHAGUS**

**Arterial Supply** – Cervical Oesophagus – Inferior thyroid artery and Left Subclavian Artery.

Thoracic part has a segmental supply directly from the Descending Aorta and branches of the Bronchial and upper Posterior Intercostal Arteries.

The abdominal part is supplied by the left gastric artery, a branch of the coeliac artery, and the left inferior phrenic artery directly from the abdominal aorta.

**Venous Drainage** – in a segmental manner in Inferior thyroid vein, Azygous, Hemiazygous (Systemic drainage) and Left gastric vein (Portal drainage).

The lower end of the oesophagus is an important area of portal systemic venous anastomosis.
Lymphatic – lie in mucous membrane and in muscular coat
Cervical lymphatic drain in lower deep cervical and paratracheal nodes.
Thoracic – Posterior mediastinal and tracheobronchial nodes
Abdominal – left gastric nodes.