

Lecture 18 – Pharynx, larynx, swallowing, and voice

Pharynx (Moore pp 1049, Netter Plate 57/60)

The pharynx is composed of three parts. Nasopharynx: extends from the posterior nasal cavity behind the choanae, inferiorly to the soft palate (respiratory system), Oropharynx: posterior to the oral cavity, between soft palate and epiglottis, Laryngopharynx (hypopharynx): posterior to larynx. The pharynx continues inferiorly to the inferior border of the cricoid cartilage anteriorly, and C6 vertebrae posteriorly.

Identify the three parts in your atlas.

Anterior side of pharynx (Notes, Netter Plate 60)

Here we are looking at the pharynx from a posterior view. Therefore, we are looking at the anterior side of the pharynx. Identify the following structures: Choanae (2), soft palate (uvula), oral cavity, root of tongue (posterior tongue), laryngeal inlet (aditus), and posterior surface of larynx.

Posterior aspect of pharynx (Moore pp 1050 – Fig 8.35, Netter Plate 57/59)

Looking at the posterior aspect of the pharynx, identify the following structures: buccopharyngeal part of the visceral layer of deep cervical fascia (buccopharyngeal fascia), retropharyngeal space, prevertebral space, anterior longitudinal ligament of vertebrae. Infection can occur in the retropharyngeal space.

Muscles of pharynx (Moore pp 1055, Netter Plate 59/61)

The muscles of the pharynx are arranged in the following fashion: external circular layers & internal longitudinal layers. The internal longitudinal layer of muscles consists of: palatopharyngeus, stylopharyngeus, and salpingopharyngeus muscles. The external layer of muscles is formed by the three pharyngeal constrictor muscles namely: superior, middle and inferior. Between these muscles are spaces for vessels/nerves/ligaments/muscles to go through. These muscles originate from the pterygomandibular raphe, hyoid bone, and thyroid/cricoid cartilages respectively.

Nasopharynx (Moore pp 1050, Netter Plate 57)

The roof of the nasopharynx is formed by the sphenoid and occipital bone. Looking posterolaterally you can see the superior pharyngeal constrictor, and pharyngobasilar fascia. The pharyngotympanic tube opens into the nasopharynx via the pharyngeal opening. The salpingopharyngeal fold lies just inferiorly to the auditory opening, and this covers the salpingopharyngeus muscle – which opens the pharyngeal orifice during swallowing – equalising pressure on either sides of the tympanic membrane. The lymphoid tissue in the superior and lateral part of the nasopharynx are called the adenoids (pharyngeal tonsil).

Pharyngotympanic (auditory, Eustachian) tube (Notes, Netter Plate 87)

The auditory tube connects the nasopharynx to the middle ear (tympanic cavity). This provides a nice avenue for infection spread from the nasal cavity to the middle ear and mastoid cells (mastoid antrum) – otitis media. The salpingopharyngeus muscle is responsible for opening the pharyngeal orifice of the auditory tube during swallowing – therefore – equalising the pressure on opposite sides of the tympanic membrane.

Oropharynx (Moore pp 1051 Fig 8.37, Netter Plate 57/58)

The oropharynx extends from the soft palate to the top of the epiglottis, on the posterior aspect of the oral cavity. The boundary between the oral cavity and oropharynx is called – fauces. There are two main arches here: palatoglossus + palatopharyngeus (contains their respective muscles). The palatine tonsil sites between these two arches – tonsillar cleft. The lingual tonsil, makes up the posterior 1/3 of the tongue – close association with the fauces (Netter Plate 58). The oropharynx houses the gap – between the superior and middle pharyngeal constrictor muscle – and through this goes: stylohyoid ligament, stylopharyngeus muscle, glossopharyngeal nerve (CN IX).

Laryngopharynx (hypopharynx) (Moore pp 1053 Fig 8.36, Netter Plate 57-60)

The laryngopharynx extends from the superior epiglottis to the inferior border of the cricoid cartilage, lying posterior to the larynx. It is continuous with the oesophagus inferiorly. Note there is a small space (valleculae) between the tongue and epiglottis, hence small food scraps may get caught here. The piriform recess is a small depression on either side of the laryngeal inlet, where deep to the mucosa lies branches of the internal and recurrent laryngeal nerve. Thus, any lodgement of foreign body here could damage these nerves.

Swallowing (Moore pp 1053 Fig 8.39)

The act of swallowing is partly a voluntary & involuntary process. There are three main stages:

1. Voluntary: food is chewed, mixed with saliva to form soft bolus. Bolus is pushed from mouth to oropharynx mainly by contraction of muscles of tongue + palate.
2. Involuntary: soft palate is elevated sealing off nasopharynx (avoid food entering nasal cavity), elevation of pharynx and larynx occurs (contraction of suprahyoid and pharyngeal muscles) therefore food is directed to oesophagus
3. Involuntary: sequential contraction of all three pharyngeal constrictors forcing food bolus down to oesophagus

Normally the start of the oesophagus is constricted when not swallowing. This constriction is provided by the cricopharyngeus part of the inferior pharyngeus muscle – thereby preventing gastric juice to enter the pharynx.

Innervation of muscles of pharynx (Moore pp 1056 Table 8.6)

Recall there are 6 muscles of the pharynx organised as internal and external layers. The internal layers are: palatopharyngeus, stylopharyngeus, and salpingopharyngeus. The external layers are: superior, middle, inferior pharyngeal constrictors. All pharyngeal muscles (except for stylopharyngeus) is supplied by vagus nerve (CN X) – where stylopharyngeus is supplied glossopharyngeal nerve (CN IX).

Nucleus ambiguus consists of cells bodies of neurons supplying CN IX + X. Thus, LMNs for these muscles are located in nucleus ambiguus (medulla) Fig: 12-2 Nolte 5th Ed pp 294).

Course of IX and X in cranial cavity (Netter Plate 108)

Locate CN IX + X in Netter Plate 108. Notice they exit the brain stem at the post – olivary, as apposed to CN XII (pre-olivary sulcus). These nerves exit the brainstem through the jugular foramen.

UMN control over nucleus ambiguus LMNs: Corticobulbar tract

Primary motor cell bodies are located in the precentral gyrus (primary motor cortex) and nearby areas (primary somatosensory cortex). Axons travel through the internal capsule, cerebral peduncle of midbrain and basal pons. Then axons split bilaterally to supply the nucleus ambiguus in the medulla. So UMNs supply LMNs bilaterally.

Sensory innervation of pharynx (Moore pp 1058)

Sensory innervation of the three parts of the pharynx is mainly provided by the glossopharyngeal nerve. Sensory innervation of the anterior & superior parts of the nasopharynx derive from V₂. The gag reflex is clinically useful (although unpleasant) to test CN IX + X together. Touching one side of the pharynx, will produce a bilateral gag. The afferent limb is via the glossopharyngeal nerve (CN IX) whilst the efferent limb is via the vagus nerve (CN X). The central connections are thought to involve: spinal trigeminal nucleus (V), solitary tract + nucleus (IX + X) and nucleus ambiguus (IX + X).

Summary of central pathways for sensation from pharynx (Notes, Cranial Nerve Summary Lecture)

Note that general sensation from the pharynx is via CN IX, X, V₂. Primary sensory cell bodies afferents travelling via CN IX + X are located in the inferior ganglion. These project to the nucleus of solitary tract. 2^o neurons located here project to three locations: dorsal motor nucleus of X, hypothalamus, and nucleus ambiguus.

Primary sensory cell bodies travelling via CN V₂ are located in the V ganglion. These project to main sensory nucleus and spinal V nucleus (via spinal V tract). 2^o neurons here cross the

midline and ascend as the trigeminothalamic tract to VPM of thalamus. 3^o neurons project to post central gyrus cerebral cortex.

Lymphatics and vessels of pharynx (Moore pp 1058 Fig 8.41, Netter Plate 63/64/66)

There are lymphoid aggregations in the pharynx, described above. These are: palatine, lingual & adenoids (pharyngeal + tubal tonsils). Lymphatic drainage of the pharynx occurs via the retropharyngeal nodes → deep cervical nodes along IJV (within the carotid sheath). Blood supply to the pharynx: ascending/descending palatine artery, superior and inferior thyroid artery.

Larynx (Moore pp 1038, Netter Plate 71)

The larynx forms superior to the trachea, and inferior to oropharynx. It is part of the respiratory system and is responsible for phonation. It continues from the laryngeal inlet and is continuous with the trachea.

Skeleton of larynx (Moore pp 1038, Netter Plate 71)

The skeleton of the larynx is made up of several cartilages, joined by ligaments and membranes. These cartilages are: (single) – thyroid, cricoid, epiglottic, (paired) – arytenoid, corniculate, cuneiform. The membranes and ligaments are: thyrohyoid, cricothyroid, cricotracheal, thyroepiglottic & vocal ligaments. Identify these structures on Netter Plate 71, Moore pp Fig 8.27A-D.

Interior of larynx (Moore pp 1041, Fig 8.29 – Netter Plate 72)

The larynx is split into three subdivisions: 1) vestibule of larynx – superior to the vestibular fold (false vocal cords – Netter Plate 75) up to laryngeal inlet, 2) ventricle – between the vestibular fold and vocal fold, 3) Infraglottic cavity – from vocal folds to inferior border of cricoid cartilage.

The aryepiglottic fold is a mucosal fold from the arytenoid cartilage → epiglottic cartilage. Note that it contains the cuneiform tubercle (i.e.: cuneiform cartilage).

Vocal folds (Moore pp 1041 Netter Plate 72)

Note that the arytenoid cartilage has a muscular process (laterally) and vocal process (medially). The vocal fold (true vocal cords) is made up of this vocal process of the arytenoid cartilage, vocal ligament, and vocalis muscle (most medial part of thyroarytenoid muscle). The glottis is the vocal folds + rima glottidis (aperture in between). The shape of the rima glottidis varies according to the position of the vocal cords.

During normal respiration the vocal folds are slightly abducted. During forced expiration – the vocal chords are fully abducted. During phonation the vocal folds are closely opposed – adducted - (not tightly).

Muscles of the larynx (Moore pp 1044, Netter Plate 72/73)

Note that the arytenoid cartilages can slide medially and laterally or rotate in order to produce abduction/adduction of vocal cords. Therefore these cartilages control abduction/adduction.

The laryngeal muscles can be divided into intrinsic/extrinsic groups. The extrinsic muscle groups (discussed as part of the anterior triangle) move the larynx as a whole. The infrahyoids depress the cricoid cartilage and larynx, while the suprahyoids elevate the cricoid cartilage and larynx. The **intrinsic muscles** move the vocal cords – controlling the length and tension of vocal cords – and size of rima glottidis.

There are six intrinsic laryngeal muscles in all. They are: posterior cricoarytenoids: only muscle that abducts vocal folds (i.e.; pulls muscular process together), lateral + transverse cricoarytenoids adduct the vocal folds → phonation (i.e.: former – pushes muscular process apart, latter – slides arytenoid cartilage medially), cricothyroid tenses (↑ length) vocal folds (i.e.: ↑ pitch), vocalis muscle located within vocal folds adjusts tension on vocal cord, thyroarytenoid muscle relaxes vocal cords (i.e.: shortens it), oblique arytenoid, aryepiglottic, thyroepiglottic – all close off laryngeal inlet during swallowing by adducting aryepiglottic folds and pulling epiglottis posteriorly (wrapping movement – Netter Plate 72 – posterior view).

Piriform recess – revisited (Notes)

Note that the piriform recess is between the thyroid and cricoid cartilages (anteroposteriorly) and aryepiglottic folds (medially). The internal branch of superior laryngeal nerve runs in the mucosa overlying the piriform recess.

Innervation of laryngeal muscles (Moore pp 1045 Table 8.5, Netter Plate 74)

Note that all the laryngeal skeletal muscles (except for cricothyroid muscle) are innervated by vagus nerve (CN X) via recurrent laryngeal nerve. The cricothyroid muscle is innervated by the external laryngeal nerve – a branch of the superior laryngeal nerve (also CN X).

The LMNs innervating these muscles (i.e.: vagus nerve CN X) are located in nucleus ambiguus. Remember nucleus ambiguus receives bilateral innervation from the UMNs via the corticobulbar tract.

Sensory innervation of larynx (Moore pp 1047 Netter Plate 74)

The sensory innervation of the larynx is supplied by the vagus nerve (CN X). Sensation above the vocal folds is done by the internal branch of the superior laryngeal nerve, while sensation below the vocal folds is done by the recurrent laryngeal nerve. The cough reflex occurs if a foreign particle tries to enter the larynx. The afferent limb is mediated by CN X, while the efferent limb is mediated by CN X + other nerves (i.e.: abdominal muscles contract etc).

Phonation (vocalisation) (Moore pp 1044-1047, Netter Plate 72/73)

Remember phonation occurs due to adduction & change in lengths of vocal folds. The muscles that mediate these actions are as follows: adduction – lateral and transverse cricoarytenoids, adjust tension – vocalis, change length of vocal cords – cricothyroid tenses the cords (lengthens) while thyroarytenoids (shorten) relax the cords.

The adjustments provided by the vocalis manifests as pitch adjustment (i.e.: high/low pitch).

Damage to laryngeal nerves (Notes)

If there is damage to one recurrent laryngeal nerve then: you would have paralyse of all the ipsilateral intrinsic laryngeal muscles (except cricothyroid). Therefore you would not be able to abduct/adduct ipsilateral vocal cord – therefore voice production is poor. If both recurrent laryngeal nerves are damaged, then you would have bilateral paralyse of all the intrinsic laryngeal muscles (except both cricothyroids) – therefore both vocal cords can be adducted/abducted – therefore voice production is almost absent.

If the superior laryngeal nerve is damaged then you lose motor innervation to cricothyroid muscle. Therefore the vocal folds cant be lengthed – tensed. Therefore high pitch voice is lost. Also the superior laryngeal nerve provides sensory innervation of the upper larynx, therefore if it is damaged – then cough reflex is absent.

Dysarthria vs aphasia (Notes)

Phonation is not only dependent on movement of the vocal cords, it is also dependent on: larynx (X), tongue (XII), palate (X), lips (VII), mouth (V), suprahyoid/infrahyoid muscles (various nerves). Dysarthria – disturbance of articulation of speech – typically caused by LMN (brainstem) or cranial nerve problem. Aphasia – problems with production (Broca's area) /comprehension (Wernicke's area) of speech, problems with writing as well (cerebral cortex problem).

Lymphatics and vessels of larynx: Lymphatics → DCN → IJV, blood: sup/inf laryngeal aa/vv from sup/inf thyroid aa/vv.