

Section 1

Introduction

Chapter

1

Clinical head and neck anatomy for the ENT anesthesiologist

Nicole M. Fowler and Joseph Scharpf

Introduction

An understanding of anatomy is paramount to the ability to safely anesthetize the head and neck surgery patient. In contrast to other patient populations, the head and neck surgery patient's pathology may obfuscate normal anatomy and impede or even prevent the anesthesiologist from being able to intubate the patient. Furthermore, recognized anatomic variations may complicate the anesthesiologist's management of the patient. Cooperation among the entire operating team is the key to a successful operation. The surgeon and anesthesiologist must discuss the particular patient's anatomy and specific procedural needs prior to each case. Potential airway management options such as routine oral intubation, nasotracheal intubation, awake fiberoptic intubation and even awake tracheotomy must be considered. Contemporary technological advances can enhance this discussion by including photography and videography. For example, computerized imaging systems in use in modern operating rooms can be synchronized to a server in the otolaryngology clinic to allow the review of both photographs and videos of patients' airways and the extent that they have been altered through disease progression. While the added dimension of visual review integrated into the discussion can be an invaluable adjunct to this team approach, always bear in mind that conditions could have worsened significantly since the imaging was performed.

Patient safety concerns continue to be increasingly recognized as a vital component of modern health care. At the authors' institution we perform both an operative "huddle" with the patient awake and a surgical "time-out" prior to performing any procedure. The huddle is an ideal time to review the intubation

plan including the use or avoidance of long-acting muscle relaxants for the case. The huddle process also ensures that both the anesthesiologist and surgeon are present and ready to handle any potential perioperative complications. The head and neck surgeon should be considered an airway specialist and partner with the anesthesiologist.

Face anatomy

The basic underlying structure of the face is formed by the skull, facial bones and mandible (Figure 1.1). The skull is formed by a series of eight bones: paired parietal and temporal bones and single frontal, occipital, sphenoid and ethmoid bones [1]. The facial skeleton creates the anterior portion of the skull and includes the orbits, nares, maxilla and mandible. The face is formed by 12 uniquely shaped bones: paired lacrimal bones, nasal bones, maxillae, zygomatic and palatine bones and a single vomer and mandible. The maxillae and mandible support the teeth (Figure 1.1). The teeth are numbered from superior right to left and inferior left to right from 1 to 32 for adults and lettered A–T in the same order for pediatric primary dentition. Normal occlusion, also termed class I occlusion, is defined by the mesiobuccal cusp of the first maxillary molar impacting the mesiobuccal groove of the first mandibular molar [2]. Class II occlusion, commonly referred to as retrognathic, occurs when the mesiobuccal cusp of the first maxillary molar impacts mesial to the groove (overbite). Class III occlusion, commonly referred to as prognathic, occurs when the mesiobuccal cusp of the first maxillary molar impacts distal to the groove (underbite).

Trauma resulting in facial fractures can complicate intubation. Mandibular fractures are usually

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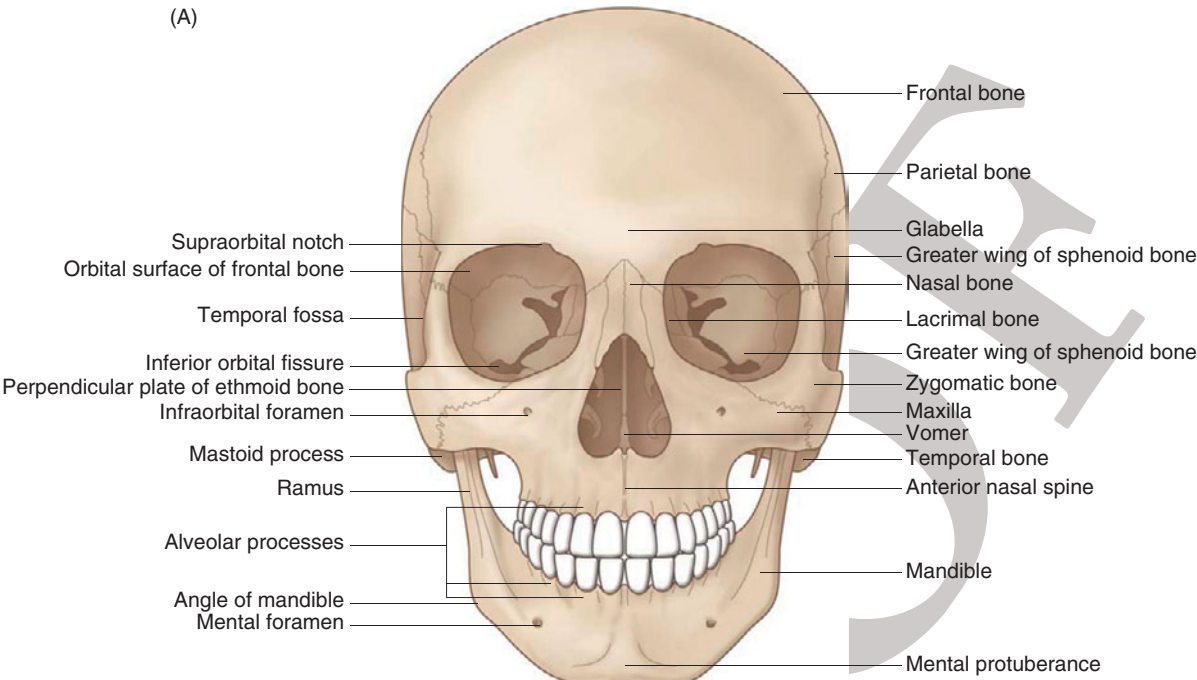


Figure 1.1. Anterior cranium and overlying facial topography. Artwork created by Emily Evans.

paired and occur on opposite sides of the mandible. Fractures of the maxillae are commonly categorized based on the Le Fort classification [3]. Le Fort I fracture is a horizontal fracture of the maxilla superior to the alveolar process and the pterygoid plates of the sphenoid. Le Fort II fractures involve an oblique fracture of the maxillary sinus and horizontal fractures of the lacrimal and ethmoid bones across the nose resulting in an unstable midface where the hard palate is separated from the skull. Le Fort III fractures involve a horizontal fracture through the superior orbital fissure, the ethmoid and nasal bones through the greater wing of the sphenoid bone and frontozygomatic sutures. This may occur in conjunction with fractures of the zygomatic arches resulting in an unstable midface where the maxilla and zygomatic bones are no longer attached to the skull. If significant facial trauma has occurred the patient may have resulting skull and brain injuries which may supersede treatment of the facial injuries. Depending on the severity of the trauma, the airway may have been triaged in the field and an emergency cricothyroidotomy or tracheotomy may have already been performed if an oral intubation was not possible. When

preparing to intubate a patient with a mandibular fracture carefully evaluate the teeth as the tooth roots are areas of bony weakness and may be involved in the fracture. Orbital fractures commonly of the inferior orbital rim may result in entrapment of the extraocular muscles; particularly the inferior rectus can result in activation of the oculocardiac reflex [4]. This reflex between the trigeminal and vagus nerve can result in bradycardia, a junctional rhythm, asystole or even death. Treatment includes surgical release of the muscle, atropine or glycopyrrolate.

Face shape is determined by the bones, muscles and subcutaneous tissue (Figure 1.2). The muscles of facial expression lie within the subcutaneous tissue. The muscles of facial expression are innervated by the facial nerve. They generally attach to bone or fascia and act by pulling the skin to create facial expression. When performing surgery around the facial nerve or its branches, including otologic procedures, parotidectomy, submandibular gland excision and neck dissections, neuromuscular blockade is contraindicated and all or part of the ipsilateral face may need to be included in the surgical field for monitoring.

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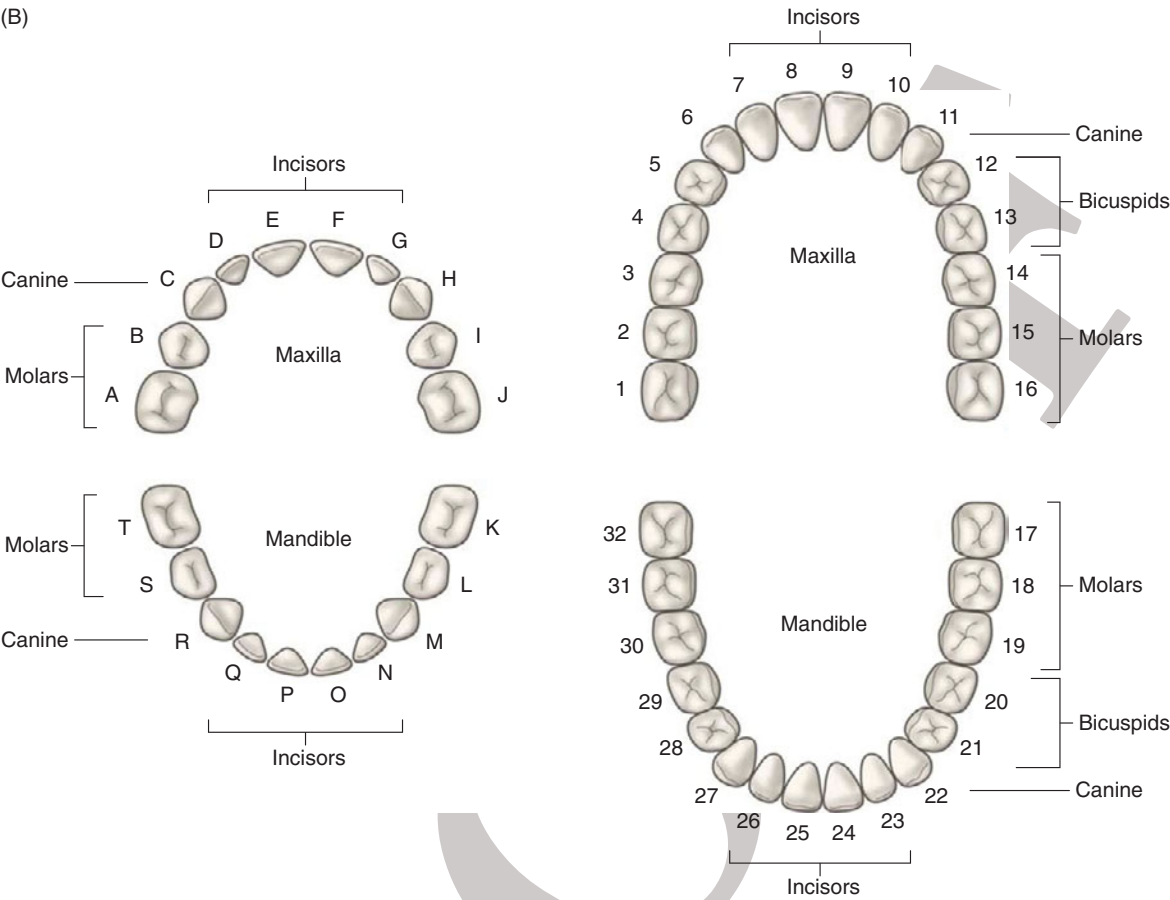


Figure 1.1. (cont.)

Ear anatomy

The ear is divided into three parts: the external, middle and internal. The external ear (Figure 1.3) includes the external auditory canal to the tympanic membrane. This is approximately 2–3 cm in length. The lateral one-third is cartilaginous and the inner two-thirds is composed of skin directly on the periosteum of the tympanic portion of the temporal bone. The middle ear is an air-filled cavity containing the three auricular ossicles – the malleus, incus, and stapes. The middle ear pressure is regulated by the eustachian tube, which opens into the nasopharynx. The inner ear is contained within the petrous portion of the temporal bone and includes the cochlea, vestibule and semicircular canals. The cochlear hair cells activate the cochlear nerve, resulting in hearing transmission. The vestibule is a small oval chamber

containing the saccule and utricle, which along with the semicircular canals control balance. The labyrinthine and tympanic portions of the facial nerve lie in close proximity to these structures and may be dehiscient, necessitating lack of neuromuscular blockade and close monitoring of facial movements during certain otologic procedures.

Nose anatomy

The nose projects from the face largely based on the amount of cartilage. Extending from the nasal bone are the upper and lower lateral cartilages. Stability is provided from the underlying nasal septum which is also composed of both bone and cartilage. The posterior bony septum is formed from the perpendicular plate of the ethmoid and vomer but the majority of the septum, the anterior septum, is the quadrangular

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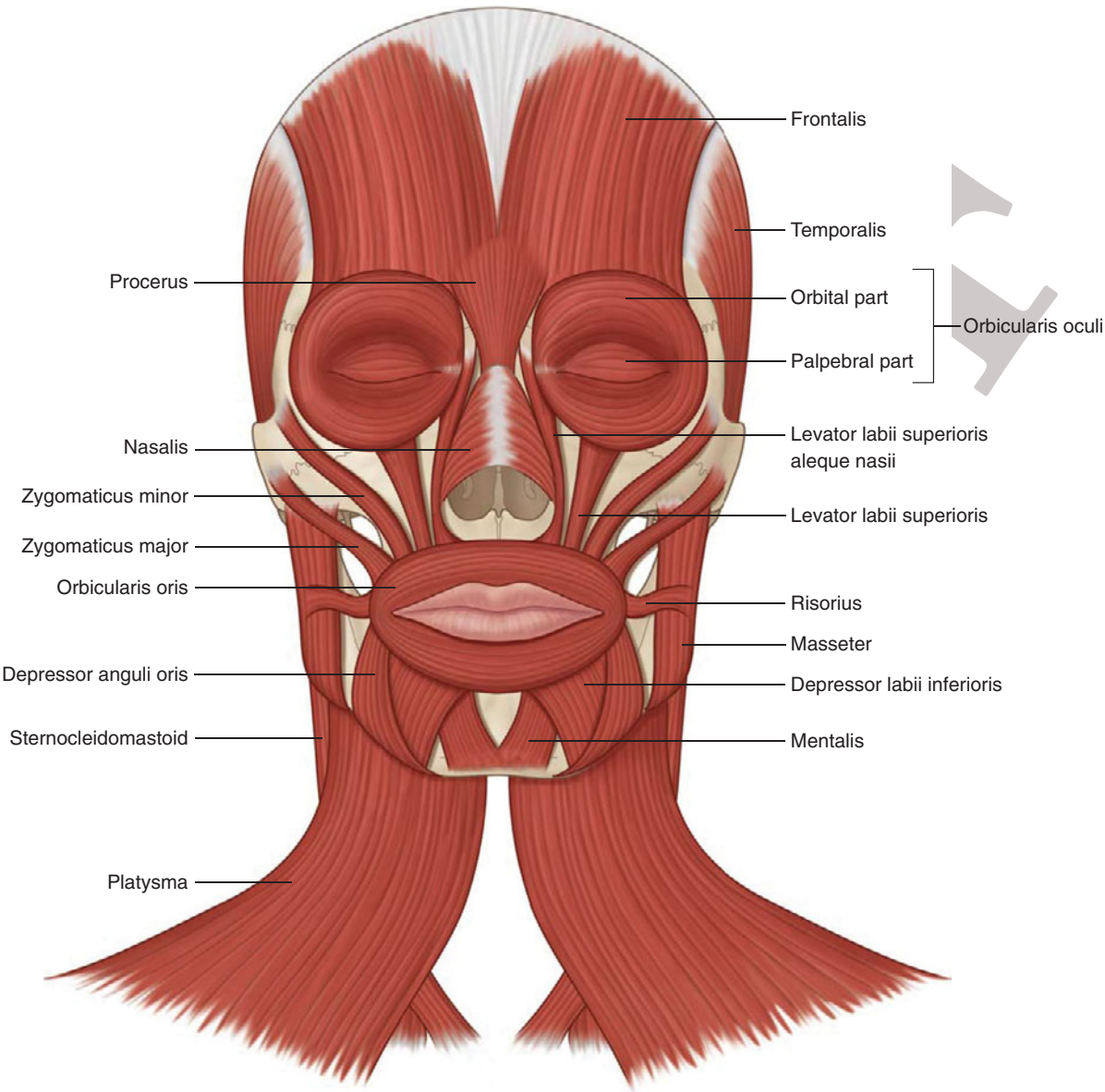


Figure 1.2. Muscles of facial expression. Artwork created by Emily Evans.

cartilage. The nasal ala are supported by U-shaped alar cartilage which is free and mobile, allowing the dilatation or constriction of each nostril. In preparation for a nasotracheal intubation or a fiberoptic intubation the nares should be examined for any septal deviation. The degree and site of deviation may help decide which nostril to use for the intubation. Care must be taken when placing any foreign object into the nose because of its robust blood

supply. The anterior nasal septal area is referred to as Kiesselbach's plexus and is the site of a capillary anastomosis from the sphenopalatine artery, anterior and posterior ethmoid arteries, greater palatine artery and the superior labial artery. Any object placed into the nose should be directed along the floor of the nose, which is wider than the roof. In preparation for any nasal manipulation the nasal mucosa should be treated with a vasoconstrictor and anesthetic.

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Figure 1.3. External ear structure.
Artwork created by Emily Evans.

A vasoconstrictor such as phenylephrine or oxymetazoline will act on the erectile tissues of the nasal mucosa and result in decongestion and opening of the nasal passages. If profuse bleeding occurs pressure should be applied, and medications such as oxymetazoline (Afrin), phenylephrine or an epinephrine-soaked pledget can be placed into the nares. Following successful nasotracheal intubation extreme care must be taken to position the nasotracheal tube such that it is not applying pressure to the nasal alar skin. Even slight pressure can result in necrosis of the alar skin. Within each nostril are the three turbinates, inferior, middle and superior, which increase the surface area for humidification and warming of the inspired air. The paranasal sinuses are air-filled spaces extending into the frontal, ethmoid, sphenoid and maxillary bones. Since the advent of the endoscope much of rhinology has become endoscopic.

Mouth anatomy

The mouth is subdivided into the oral cavity and the oropharynx. The oral cavity begins at the skin-vermilion junction of the lips and extends posteriorly to the junction of the hard and soft palate superiorly and to the line of the circumvallate papillae on the tongue inferiorly. The oral cavity therefore includes the lips, buccal mucosa, maxillary and mandibular alveolar ridges/teeth/gingival, floor of the mouth, hard palate, the retromolar trigone and the anterior oral tongue (Figure 1.4). The hard palate forms the roof of the mouth and separates the oral cavity from the anterior nasal vault. It is composed of the palatine

process of the maxilla and the horizontal plate of the palatine bone. Figure 1.5 shows a rare primary palatal tumor. Tumors are very friable and will bleed easily so in this patient great care was taken to avoid any manipulation of the palate. The retromolar trigone is a triangular area just anterior to the ascending ramus of the mandible. A triangle is drawn with its medial aspect coinciding with the anterior tonsillar pillar, the base being across the mandibular alveolus posterior to the last molar and its apex being the coronoid process. In this area the mucosa is tightly adherent to the ascending ramus of the mandible. Carcinomas originating in this region tend to invade the mandibular periosteum and medial pterygoid muscle causing significant trismus. Referred otalgia is also a common symptom due to innervation by the mandibular branch of the trigeminal nerve, the lesser palatine nerve and the glossopharyngeal nerve. The circumvallate papillae and terminal sulcus divide the tongue into an anterior two-thirds and posterior one-third. The anterior two-thirds of the tongue can largely be easily visualized by the patient and clinician. Patients will routinely present with a small non-healing ulcer or sore lesion. The oral tongue is composed of three extrinsic tongue muscles: the genioglossus, hyoglossus and styloglossus muscles (Figure 1.6; Table 1.1a). In combination with the intrinsic tongue musculature these muscles assist with speech articulation and deglutition. The tongue musculature is innervated by the hypoglossal nerve (CNXII). Taste to the anterior oral tongue is supplied by the lingual nerve (CNV3) having received fibers from the chorda typani nerve. As these nerve fibers travel with those to the external ear, external auditory

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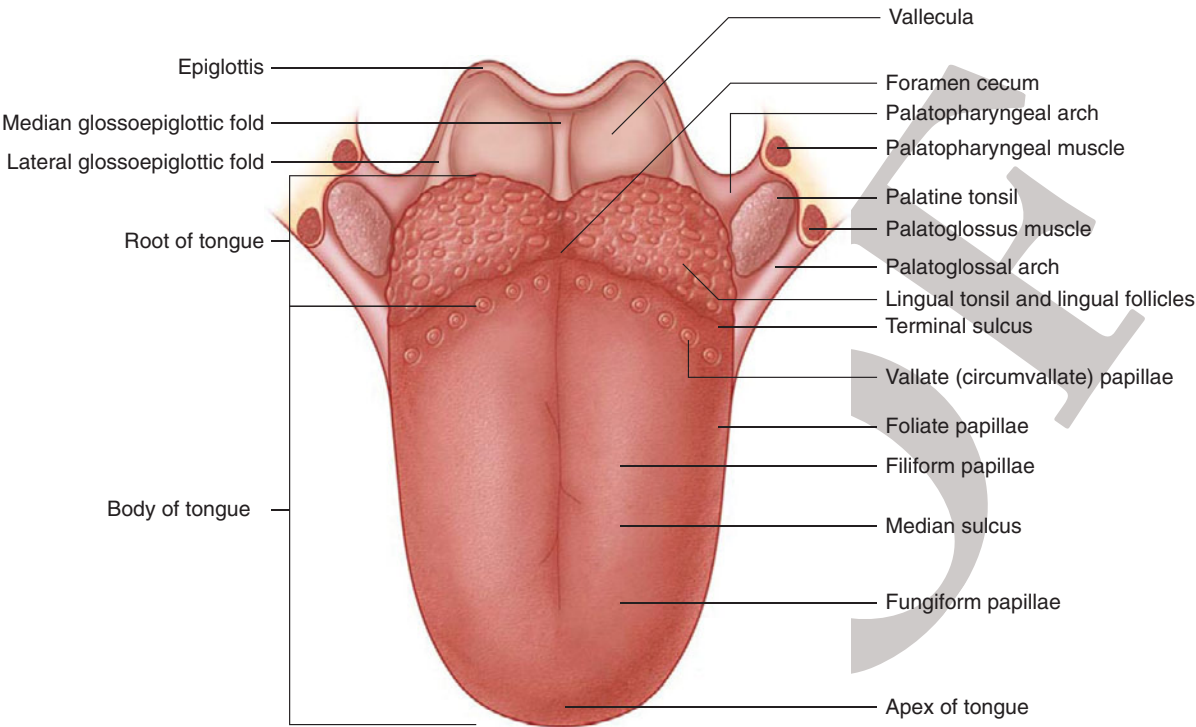


Figure 1.4. Dorsal tongue anatomy. Artwork created by Emily Evans.



Figure 1.5. Photo of primary palatal tumor. Photo courtesy of Dr. Joseph Scharpf.

canal and tympanic membrane referred otalgia is a common presenting symptom with tongue cancers. Lateral tongue cancers drain to the ipsilateral level IB or II nodes. The medial tongue may drain directly to level III. The tip of the tongue drains to level IA. The floor of the mouth is the mucosa lying between the mandibular alveolus and the oral tongue. This area is

pierced by the submandibular gland duct (Wharton's duct) bilaterally on either side of the lingual frenulum. The length and site of attachment of the lingual frenulum on the ventral surface of the tongue can affect tongue protrusion. Tethering of the tongue is termed ankyloglossus and can be surgically cut if it affects speech articulation or feeding as an infant. Odontogenic infections can become life-threatening if they spread into the submental or submandibular spaces. Ludwig's angina is a severe infection involving the floor of mouth. As the infection and swelling worsens the tongue is pushed posteriorly and superiorly, causing respiratory obstruction. The patient may have marked trismus in addition to odynophagia and may have dysphagia to the extent that they cannot tolerate their own secretions. Infections in this space are considered an airway emergency and may require an awake tracheotomy for management. Complete airway obstruction is the most frequent cause of death from this disease [2]. The oropharynx extends from an imaginary line extending back from the hard palate superiorly to the level of the hyoid bone inferiorly and includes the soft palate, tonsils, base of tongue and posterior pharyngeal wall. This

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Table 1.1a. Muscles of the soft palate. Reproduced with permission from Olson TR, Pawlina W. *ADAM Student Atlas of Anatomy*. Cambridge University Press, 2008

Muscle	Superior attachment	Inferior attachment	Innervation	Main actions
Levator veli palatini	Cartilage of auditory tube and petrous part of temporal bone	Palatine aponeurosis	Pharyngeal br. Of vagus n. via pharyngeal plexus (CN X)	Elevates soft palate during swallowing and yawning
Tensor veli palatini	Scaphoid fossa of medial pterygoid plate, spine of sphenoid bone & cartilage of auditory tube		Medial pterygoid n. (a br. Of the mandibular n.) via otic ganglion (CN V ³)	Tenses soft palate and opens cartilagenous part of auditory tube during swallowing and yawning
Palatoglossus	Palatine aponeurosis	Side of tongue	Pharyngeal br. Of vagus n. (CN X) via pharyngeal plexus	Elevates posterior part of tongue and draws soft palate onto tongue
Palatopharyngeus	Hard palate and palatine aponeurosis	Lateral wall of pharynx		Tenses soft palate and pulls walls of pharynx superiorly, anteriorly, and medially during swallowing
Musculus uvulae	Posterior nasal spine and palatine aponeurosis	Mucosa of uvula		Shortens uvula and pulls it superiorly

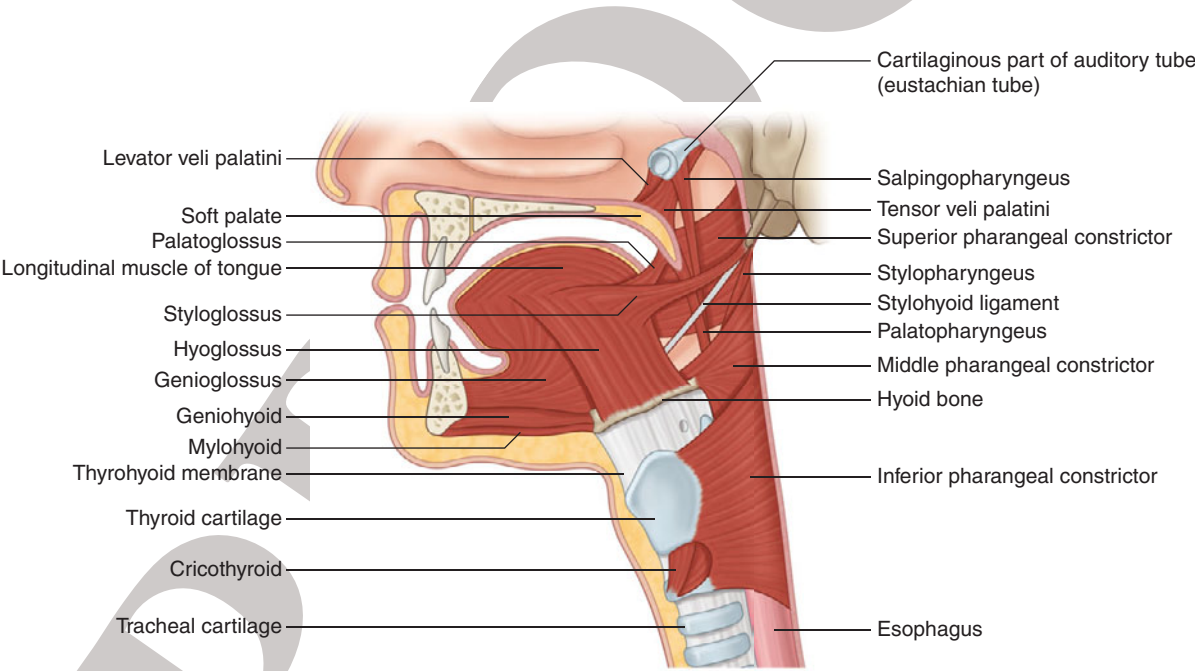


Figure 1.6. Sagittal view of the pharyngeal musculature. Artwork created by Emily Evans.

area is much more difficult to visualize for both the patient and the clinician. The pharyngeal walls are composed of mucosa, submucosa, pharyngobasilar fascia, the superior and upper middle constrictor muscle, and buccopharyngeal fascia (Figure 1.7; Table

1.1b and Table 1.2). Posterior to the buccopharyngeal fascia is the retropharyngeal space. This potential space exists between the buccopharyngeal fascia and the alar layer of the prevertebral fascia (Figure 1.7). This space extends from the skull base to the superior

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Table 1.1b. Extrinsic muscles of the tongue. Reproduced with permission from Olson TR, Pawlina W. *ADAM Student Atlas of Anatomy*. Cambridge University Press, 2008

Muscle	Stable attachment	Mobile attachment	Innervation	Actions
Genioglossus	Sup. part of mental spine of mandible	Dorsum of tongue and body of hyoid bone	Hypoglossal n. CN XII	Protrudes, retracts and depresses tongue; its post. part protrudes tongue
Hyoglossus	Body and greater horn of hyoid bone	Side of tongue		Depresses and retracts tongue
Styloglossus	Styloid process and stylohyoid lig.	Side and inf. aspect of tongue		Retracts tongue and draws it up to create a trough for swallowing
Palatoglossus	Palatine aponeurosis of soft palate	Side of tongue	Pharyngeal br. CN X and pharyngeal plexus	Elevates post. part of tongue

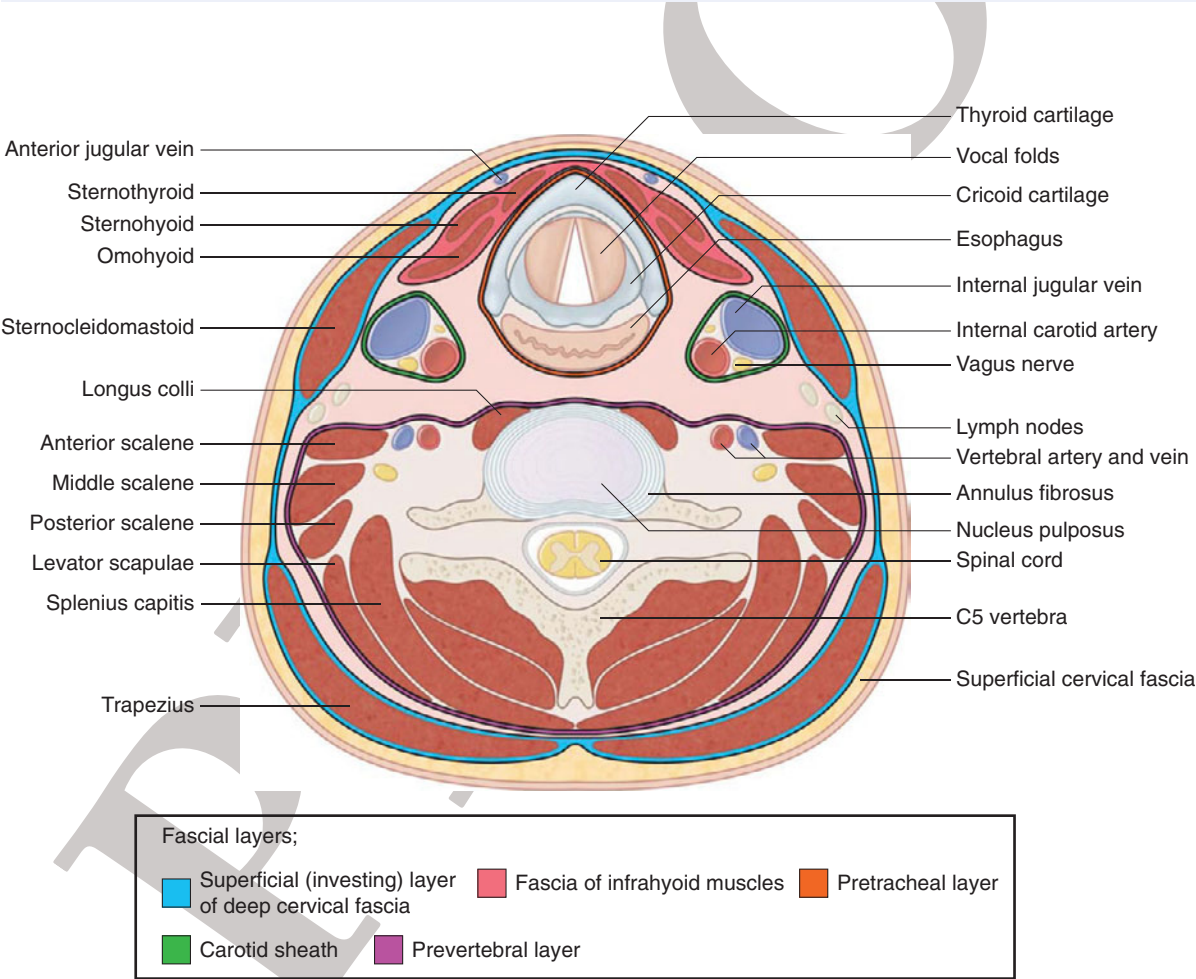


Figure 1.7. Divisions of the cervical fascia. Artwork created by Emily Evans.

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Table 1.2. Pharyngeal muscles Reproduced with permission from Olson TR, Pawlina W. *ADAM Student Atlas of Anatomy*. Cambridge University Press, 2008

Muscle	Lateral attachments	Medial attachments	Innervation	Main actions
Circular pharyngeal muscles				
Superior constrictor	Pterygoid hamulus, pterygomandibular raphe, post. end of mylohyoid line of mandible and side of tongue	Median raphe of pharynx and pharyngeal tubercle	Pharyngeal and sup. laryngeal brr. of vagus n. [CN X] through pharyngeal plexus	Constrict wall of pharynx during swallowing
Middle constrictor	Stylohyoid lig. and greater and lesser horns of hyoid bone			
Inferior constrictor	Oblique line of thyroid cartilage and side of cricoid cartilage	Median raphe of pharynx		
Longitudinal pharyngeal muscles				
Palatopharyngeus	Hard palate and palatine aponeurosis	Post. border of lamina of thyroid cartilage and side of pharynx and esophagus	Glossopharyngeal n. [CN IX]	Elevate pharynx and larynx during swallowing, speaking ^a
Salpingopharyngeus	Cartilaginous part of auditory tube	Blends with palatopharyngeus		
Stylopharyngeus	Styloid process of temporal bone	Post. and sup. Borders of thyroid cartilage with palatopharyngeus m.		

^a The salpingopharyngeus muscle also opens the auditory tube.

mediastinum. Contingent upon the patient, his or her clinical history, and the location of a retropharyngeal space abscess in relation to the great vessels (carotid artery, internal jugular vein), the abscess may be amenable to transoral drainage versus a more traditional transcervical drainage. The tonsils are housed within a fossa created by two muscles, the anterior tonsillar pillar formed from the palatoglossus muscle and the posterior tonsillar pillar by the palatopharyngeal muscle. A small primary tonsillar or base of tongue tumor may be asymptomatic and present with metastatic cervical lymphadenopathy. Careful examination of the oral excursion is advised in any patient with a tonsillar tumor as invasion into the lateral pterygoid muscle may result in trismus, which will not improve with muscular relaxation. The soft palate is composed of the levator veli palatini, tensor veli palatini, musculus uvulae and tonsillar pillars muscles as above. The base of the tongue extends from the circumvallate papillae to the glossoepiglottic fold. The lingual tonsils are found laterally and lie in a

superficial plane creating an irregularity to the surface. Alternatively, base of tongue tumors may grow to very large sizes with minimal symptoms. Patients with a large base of tongue tumor may be able to maintain their airway but extreme caution should be taken prior to induction. An awake tracheotomy should be considered based on the anesthesiologist's experience and comfort with awake fiberoptic intubation.

The throat or pharynx is subdivided into the larynx and the hypopharynx. The larynx is further subdivided into three spaces: the supraglottis, glottis and subglottis. Furthermore the larynx is composed of nine cartilages joined by ligaments and membranes: three single cartilages: thyroid, cricoid and epiglottic; and three paired cartilages: arytenoid, corniculate and cuneiform (Figure 1.8). The largest of the cartilages, the thyroid cartilage, was so named from the Greek word thyreos, or shield, due to its shield-like appearance and its main function being that of protection of the vocal cords. It is composed

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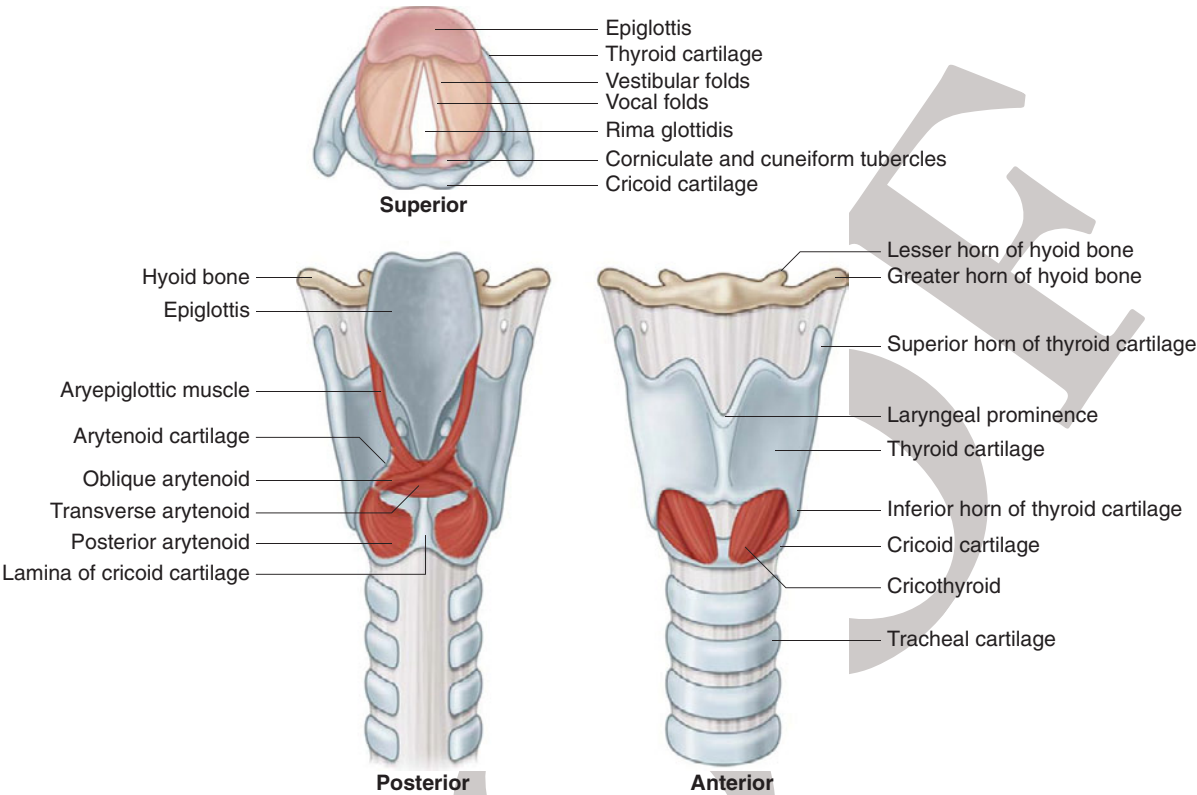


Figure 1.8. Laryngeal skeleton and musculature. Artwork created by Emily Evans.

of two large plate-like laminae which fuse in the midline forming a prominent V, which in men is termed the “Adam’s apple”. Inferior to the thyroid is the cricoid cartilage, which is shaped as a signet ring and is the only complete cartilaginous ring in the airway. In women the cricoid cartilage is the most prominent cartilaginous landmark. The cricothyroid membrane bridges the gap between the thyroid and cricoid cartilages. This cricothyroid space is easily palpable as a soft spot either inferior to the thyroid cartilage (in men) or immediately superior to the prominent cricoid cartilage (in women). This is the site of the most superficial aspect of the larynx that is externally accessible. An emergency cricothyroidotomy utilizes these critical features in an airway emergency. The two cartilages articulate at the cricothyroid joint. This joint allows rotation of the thyroid cartilage, resulting in changes in the vocal cord length and tension and ultimately changes in vocal pitch. Posteriorly the cricoid cartilage articulates with the arytenoid cartilage, forming the cricoarytenoid joint, which allows the arytenoids

to move medially and laterally, as well as tilt anteriorly and posteriorly. The vocal ligament is the skeleton on which the vocal cords form and extends from the thyroid cartilage to the arytenoid cartilages. The supraglottis begins at the top of the epiglottis to the ventricles. This includes the epiglottis (both lingual and laryngeal surfaces), arytenoids, aryepiglottic folds (AE folds) and false vocal cords. The epiglottis is a heart-shaped elastic cartilage which is pedicled off the thyroid cartilage extending superiorly. The epiglottis may be omega-shaped, retroflexed or floppy and may decrease the ability to visualize the vocal cords on intubation (depending on intubation technique). Sensation of the supraglottis is supplied by the internal branch of the superior laryngeal nerve. Figure 1.9A is a drawing of the laryngeal complex with a supraglottic mass centered in the epiglottis. Safe intubation techniques include an awake fiberoptic intubation. Figure 1.9B is a picture of an actual laryngeal complex having been removed as a total laryngectomy specimen for a patient with an extensive supraglottic tumor. The glottis includes each true