Chapter 64: Anatomy

Daniel O. Graney, Guy J. Petruzzelli, Eugene N. Myers

Pharynx

The pharynx (Fig. 64-1) is a common aerodigestive tract, which is subdivided anatomically into the nasopharynx, oropharynx, and laryngopharynx (hypopharynx). At approximately the level of the sixth cervical vertebra the pharynx ends to become the esophagus, and anterior to the pharynx the larynx ends to become the trachea. Although the pharynx in toto is not usually a site or target of surgery, areas of the lateral pharynx are often approached during total parotidectomies or surgical treatment of neoplasms. An alternate approach, for example, from the mucosal or interior surface of the pharynx, may be necessary, as in the case of a peritonsilar mass or laryngeal polyp. Thus it is important for the surgeon to understand both the medial and lateral anatomic relationships of the pharynx.

The anatomic perspective may cause disorientation and confuse surgical relationships. This chapter approaches the anatomic relationships of the entire pharynx as viewed from its lateral surface, from the skull base to the level of the cricoid cartilage. The pharynx is then rotated 90 degrees for viewing from the posterior aspect; finally it is rotated another 90 degrees for viewing the relationships from the medial surface. The key point is the constancy of anatomic relationships in a changing perspective.

Because the pharynx is constructed from three U-shaped constrictor muscles that are more narrow anteriorly than they are posteriorly, a series of four intervals occurs between the muscles, from the skull base above to the esophagus below. In the following discussion, the strategy is to describe, first, the musculoskeletal framework of the pharynx and the respective intervals between the parts of the pharynx and second, the appropriate muscles, ligaments, and accompanying neurovascular bundles filling these interspaces.

Musculoskeletal framework

The pharyngeal wall is composed of stratified squamous epithelium covering a myofascial layer extending from the skull base to the esophagus. The muscles of the pharyngeal wall are the paired superior, middle, and inferior constrictors. The fasciae of the pharyngeal wall are the well-developed dense pharyngobasilar fascia and the thinner buccopharyngeal fascia.

The pharyngobasilar fascia takes its origin at the basiocciput and extends horizontally along the petrous portion of the temporal bone to the carotid canal, at which point it turns anteriorly and attaches to the medial pterygoid lamina and pterygomandibular raphe. The buccopharyngeal fascia is a reflection of the middle layer of the deep cervical fascia and comprises the external investing layer of the superior pharyngeal constrictor and buccinator muscles. It originates at the skull base and extends into the neck to eventually fuse with the pretracheal and visceral fasciae.

The paired superior pharyngeal constrictor muscles arise from the inferior one third of the posterior border of the medial pterygoid plate and the hamulus and the pterygomandibular raphe. The fibers radiate posteriorly, inferiorly, and superiorly, condensing in the posterior midline pharyngeal raphe, which attaches superiorly at the pharyngeal tubercle. The superior constrictor is attached to the skull base at three points, the two pterygoid hamuli and the pharyngeal tubercle, thus leaving a bean-shaped interval in the posterior pharyngeal wall composed only of pharyngobasilar fascia.

Fibers of the middle pharyngeal constrictor arise from the greater and lesser cornua of the hyoid bone and the stylohyoid ligament. In an analogous fashion to the superior constrictor, the fibers of the middle constrictor radiate posteriorly, inferiorly, and superiorly, condensing in the posterior midline pharyngeal raphe, which overlaps the superior constrictor.

The inferior pharyngeal constrictor is the thickest and most well developed of the three. These fibers arise from the oblique line of the thyroid cartilage and the posterior aspect of the cricoid cartilage. The fibers of the inferior constrictor radiate posteriorly, inferiorly, and superiorly, condensing in the posterior midline pharyngeal raphe, which overlaps the middle constrictor.

The inferior pharyngeal constrictor is the thickest and most well developed of the three. These fibers arise from the oblique line of the thyroid cartilage and the posterior aspect of the cricoid cartilage. The fibers of the inferior constrictor radiate posteriorly, inferiorly, and superiorly, condensing in the posterior midline pharyngeal raphe, which overlaps the middle constrictor.

Inferiorly, at the level of the cricoid cartilage, the lowermost (horizontal) fibers of the inferior constrictor interdigitate with the transverse muscle layer of the esophagus and thicken to form the specialized cricopharyngeus muscle. The cricopharyngeus is innervated by the pharyngeal plexus (cranial nerve X) and is involved in the coordinated series of events associated with deglutition, described later in this chapter. Cricopharyngeal dysfunction has a number of causes. Idiopathic cricopharyngeal hypertonicity, cricopharyngeal achalasia, results in difficulty in swallowing or dysphagia. Systemic neuromuscular diseases, such as amyotrophic lateral sclerosis, myasthenia gravis, polymyositis, myotonic dystrophy, or muscular dystrophy, may cause cricopharyngeal dysfunction and result in uncoordinated swallowing with aspiration (Mendelsohn and McConnel, 1987). Similar symptoms may be present in patients with central nervous system pathologic conditions such as multiple sclerosis, Parkinson's disease, and Huntington's disease or following cerebrovascular accidents (Calcaterra and Ippoliti, 1990). Congenital weakness of this muscle may result in herniation of the pharyngoesophageal mucosa and development of a diverticulum. In many cases vertical sectioning of the cricopharyngeus muscle fibers (cricopharyngeal myotomy) may provide symptoatic relief.

Taken as a unit, the pharyngeal constrictors can be seen as a series of telescoping muscles with the lower fibers overlapping those above. They share a common insertion, that being the posterior pharyngeal raphe attaching at the pharyngeal tubercle. The motor innervation of the constrictors is from the external branch of the superior laryngeal nerve and the recurrent laryngeal nerve (cranial nerve X). It is uncertain whether cranial nerve IX contributes to the motor innervation of the constrictors. The blood supply to the constrictors is via the pharyngeal branches of the superior and inferior laryngeal arteries, branches of the external carotid and subclavian arteries, respectively.

A more in-depth discussion of the arrangement and function of the cricopharyngeus is given in the Chpater 119 discussion of the tracheobronchial tree.

When viewed from the lateral aspect, an interval is seen either above or below each constrictor muscle (Fig. 64-2). The first of these is between the superior constrictor and the skull base; the second is between the superior and middle constrictor muscles, although it is mostly filled in by the thyrohyoid membrane; and the fourth is between the fibers of the inferior constrictor and the esophagus. As noted previously, each of these spaces contains certain structures and is invested as well by buccopharyngeal (visceral) fascia, which is part of the internal layer of deep cervical fascia.

Interval Between Skull Base and Superior Constrictor Muscle

The interval between the skull base and the superior constrictor muscle is closed by a fascial membrane (the pharyngobasilar fascia, between the pharynx and the skull base), which is part of the buccopharyngeal fascia. In addition, two small muscles are located in the interval: the tensor veli palatini and levator veli palatini muscles (Fig. 64-3). These muscles arise from the pterygoid fossa between the lateral and medial pterygoid plates and insert into the soft palate. The tensor veli palatini is a broad, flat band of muscle, compared with the more cylindric form of the levator veli palatini.

As the tensor veli palatine fibers descend from the sphenoid bone they cross lateral to the superior constrictor muscle and course anterior to the hamulus and pterygomandibular raphe. At this point the hamulus serves as a fulcrum for the aponeurotic part of the tensor veli palatini as its fibers condense and twist into a relatively narrow band before insertnig on the anterior aspect of the soft palate (see Fig. 64-5). This portion of the soft palate is tensed by the action of the tensor veli palatini muscle. In contrast, the levator veli palatini muscle crosses the superior border of the superior constrictor and enters the nasopharyngeal mucosa and the lateral border of the soft palate.

The fibers remain as a cylindric mass until they reach the tip of the uvula. Contraction of the levator veli palatini muscle fibers elevates the soft palate and assists in sealing the oral cavity from the nasopharynx. Most authors state that the tensor veli palatini also has an important role in opening the eustachian tube (Doyle and Rood, 1980; Misurya, 1976; Procter, 1973; Ross, 1971), but others attribute this function to the levator veli palatini (Seif and Dellon, 1978).

Tensor veli palatini (TVP) dysfunction produced congenitally, experimentally, or by extirpative tumor surgery leads to middle ear dysfunction and conductive hearing loss. Congenital TVP dysfunction and resultant middle ear disease in children with cleft palates has been well described (Doyle et al, 1980). Recently, Casselbrant and co-workers (1988) have demonstrated transient eustachian tube dysfunction, negative middle ear pressure, and serous middle ear effusion in monkeys after intramuscular injection of *Clostridium botulinum* toxin into the TVP.

In a review by Myers et al (1984), approximately one fourth of patients presenting with nasopharyngeal, oropharyngeal, or maxillary antral cancers had middle ear-eustachian tube dysfunction. Tubal dysfunction was associated with large (T3 or T4) tumors. In these cases middle ear-tubal dysfunction was caused either by (1) mechanical obstruction of the torus by tumor or (2) tumor infiltration into the TVP resulting in muscle dysfunction and functional tubal obstruction. Eighty-one percent of patients with surgical resection of the TVP developed middle ear-eustachian tube dysfunction.

Also traversing the interval above the superior constrictor muscle are two arteries: the ascending pharyngeal, which arises from the bifurcation of the internal and external carotid arteries, and the ascending palatine, a branch of the facial artery. These arteries contribute to the blood supply of the palatine tonsil and adjacent mucosa.

Other important landmarks in this region are the forament spinosum and foramen ovale, which provide passage for the middle meningeal artery and mandibular branch of the trigeminal nerve, respectively (Fig. 64-3). At this point the mandibular division branches into the buccal, lingual, inferior alveolar, and auriculotemporal nerves and is the site of the otic ganglion.

Interval Between Superior and Middle Constrictor Muscles

The gap between the superior and middle constrictor muscles is filled by the prominent stylopharyngeus muscle, which originates from the styloid process. It traverses the interspace between the two constrictors and is directed inferiorly along the lateral pharyngeal wall, where its fibers insert into the fascia overlying the medial aspect of the middle constrictor. Accompanying the stylopharyngeus muscle is the ninth cranial nerve (cranial nerve IX), the glossopharyngeal, which supplies motor innervation to the muscle. After penetrating the interval between the two muscles, the glossopharyngeal nerve courses deep to the hyoglossus and enters the posterior third of the tongue, where it supplies the tongue with afferent fibers for pain, temperature, and taste. Sensory fibers are also distributed to the palatine tonsil and mucosal wall as far superiorly as the eustachian tube and to the middle ear mucosa. Because it can be confused with cranial nerve IX in the surgical field, it should be noted that the stylohyoid ligament also traverses this interval before inserting into the lesser cornu of the hyoid bone (Fig. 64-3).

Finally, the lingual artery, after arising from the external carotid artery, enters the pharynx above the superior border of the middle constrictor and parallels the course of cranial nerve IX on the medial aspect of the hyoglossus muscle. En route to the tongue it sends branches to the inferior pole of the palatine tonsil.

Interval Between Middle and Inferior Constrictor Muscles

Although the muscles do not form a continuous sheet in this area, there is no real gap between them because the space is closed by the thyrohyoid membrane. In this region, then, the structures are more accurately said to pierce the thyrohyoid membrane rather than to traverse an interval. Thus the structures piercing the thyrohyoid membrane are the superior laryngeal artery and vein and the internal laryngeal nerve. The artery arises from the superior thyroid artery as it loops onto the superior lobe of the thyroid gland. Entering the submucosa of the larynx, it supplies the mucosal wall of the piriform recess and the mucosa of the larynx. Venous drainage of this area follows the superior laryngeal vein to the superior thyroid vein, a tributary of the internal jugular.

Accompanying these vessels is the internal laryngeal nerve, which is strictly a sensory nerve from the mucosa of the piriform sinus and larynx inferiorly as far as the false vocal folds. The internal laryngeal nerve is formed when the superior laryngeal nerve divides into internal and external branches (Fig. 64-3). The superior laryngeal nerve arises as a branch of the vagus in the upper cervical area. It descends in the carotid sheath for 2 to 4 cm before dividing into the internal and external laryngeal nerves. During various laryngeal procedures the internal laryngeal nerve can be anesthetized either by application of a topical cocaine solution in the piriform sinus or by cutaneous injection with a local anesthetic through the thyrohyoid membrane and infiltrating the submucosa. The external laryngeal nerve does not enter the larynx but parallels the superior thyroid artery and the fibers of the inferior constrictor muscle, which it supplies before innervating the cricothyroid muscle. During thyroid surgery this nerve is in jeopardy when the superior thyroid artery is ligated.

Interval Between Inferior Constrictor and Esophagus

The space between the inferior constrictor muscle and the esophagus is traversed only by a neurovascular bundle, composed of the inferior laryngeal artery and vein and the recurrent laryngeal nerve. The inferior thyroid artery is one of the branches of the thyrocervical trunk from the first part of the subclavian artery. The origins of the recurrent laryngeal nerve branches of the vagus differ on the right and left sides. On the left side the branch begins at the aortic arch in the mediastinum, takes a recurrent course around the arterial ligament, and enters the tracheoesophageal groove. Ascending in the groove to the junction of the esophagus and inferior constrictor muscle, it enters the larynx and supplies motor innervation to the intrinsic laryngeal muscles. In addition, the nerve supplies sensory innervation to the mucosa of the larynx as far superiorly as the true vocal cords.

On the right side, the recurrent nerve is given off at the subclavian artery and, after looping posterior to the artery, enters the tracheoesophageal groove and ascends in a manner similar to the left. Further details of this region are discussed in Chapter 119.

Poster View of Pharynx

When the pharynx is viewed posteriorly, the muscular wall appears to be a continuous structure until it is cleared of fascia, which reveals the overlapping of the three individual pharyngeal constrictors' muscle fibers.

After the pharynx is opened by a vertical midline incision (admittedly, this is not a routine surgical approach), a unique view of the three subdivisions of the pharynx can be obtained (see Fig. 64-1). The nasopharynx begins as far as the tip of the uvula. The oropharynx is outlined by a line drawn from the tip of the uvula following along the palatopharyngeal fold to the level of the epiglottis. Finally, the laryngopharynx extends from the epiglottis to the level of the cricoid cartilage.

Each of these three regions has special mucosal landmarks as well as important anatomic relationships that underlie the mucosa. The important features of each of these regions are discussed sequentially in the following sections. For better viewing of these features the orientation is rotated another 90 degrees, which looks laterally on the mucosal regions from their medial surface (Fig. 64-4). This is in effect the "other side", or mucosal view of the pharynx - compared with the descriptions given at the beginning of the chapter, where the lateral surface is described.

Mucosal View of Nasopharynx

There are several important landmarks on the nasopharyngeal mucosa, which can be seen either on an anatomic specimen or during nasopharyngoscopy. These include the opening of the eustachian tube with its prominent ridge, the torus. The torus is the slightly enlarged cartilaginous portion of the pharyngeal end of the eustachian tube that produces a raised area of mucosa over the opening of the eustachian tube. From the posterior part of the torus the salpingopharyngeus muscle sweeps posteriorly and inferiorly, raising a mucosal fold (the salpingopharyngeal fold). The pharyngeal recess (Rosenmüller's fossa) is formed between the salpingopharyngeal fold and the wall of the pharynx by the elevation of this fold. Diffuse lymphatic nodules in the mucosa underlying the fold and pharyngeal recess form the tubal tonsil (Gerlach's tonsil). In the center of the eustachian tube opening there is usually a slight elevation of mucosa because of the underlying levator veli palatini muscle.

The roof of the nasopharynx at this point is formed by the inferior surface of the sphenoid bone and the floor of the sphenoid sinus. There is frequently a depression in the midline of the bony roof, producing a concavity of the mucosa at this point (the pharyngeal bursa). The mucosa is infiltrated with lymphatic nodules at the periphery of the pharyngeal bursa, which may be sufficiently elevated to form the pharyngeal tonsil or adenoids. Occasionally, a cystic mass (Thornwaldt's cyst) may be found in the depth of the pharyngeal bursa. This is derived from a persisting remnant of the cranial end of the embryonic notochord, which can become cystic later in life.

Slightly superior to the bursa but still in the midline of the nasopharynx is the potential site of a craniopharyngioma. This tumor is formed from residual epithelial elements of Rathke's pouch, an evagination of the stomodeal roof that contributes to the formation of the anterior lobe of the pituitary gland during embryonic development. Besides presenting as a mass in the nasopharynx, epithelial rests from the epithelium of Rathke's pouch can also be found within the sphenoid bone or as suprasellar cysts. Entrapment within the sphenoid bone occurs because the course of Rathke's pouch is through the mesenchymal anlage of the sphenoid bone before it is ossified. A parallel phenomenon, perhaps more familiar to the physician, is the entrapment of remnants of the thyroglossal duct in the hyoid bone after it is transformed from a mesenchymal mass to bone.

In addition to these midline structures, important clinical relationships exist laterally along the basisphenoid. Medial to the bony orifice of the eustachian tube lies the foramen lacerum, its fibrocartilage, and the carotid carotid canal. Anterior to the bony orifice lies the foramen spinosum and more medially, the foramen ovale. These foramina provide direct preformed pathways for nasopharyngeal carcinoma to extend intracranially from the fossa of Rosenmüller.

When the mucosa is removed from the medial aspect of the pharyngeal wall, many of the structures that traverse the interval between the skull base and the superior constrictor muscle can be seen (Fig. 64-5). As described from the lateral aspect, these are the tensor veli palatini, levator veli palatini, ascending palatine artery, and ascending pharyngeal artery. This particular view also illustrates the salpingopharyngeus muscle, which underlies the fold.

Mucosal View of Oropharynx

The oropharynx is defined superiorly by the soft palate and inferiorly by the epiglottis; it includes the tonsillar crypt and the palatine tonsil. It is limited anteriorly by the posterior third of the tongue and posteriorly by the midline wall of the pharyngeal constrictor muscles. Other landmarks of this area are the terminal sulcus and the foramen cecum.

The sulcus is the boundary between the anterior two thirds of the tongue and the posterior one third. It marks the position of the circumvallate papillae lying anterior to it. At the apex of the V-shaped sulcus is the foramen cecum, representing the site at which the thyroglossal duct pouches out from the floor of the pharynx during development of the thyroid gland. Since the anterior two thirds of the tongue lies in the oral cavity, and the posterior third of the tongue is in the oral pharynx, the terminal sulcus also divides somatic (anterior) and visceral (posterior) innervations of the tongue.

At the base of the posterior part of the tongue are two small fossae, the lingual valleculae. These are bounded by the medial glossoepiglottic fold (between the tonge base and the apex of the epiglottis) and paired lateral glossoepiglottic folds (from the lateral surface of the tongue to the lateral and inferior margins of the epiglottis).

The bed of the tonsil crypt is the lateral pharyngeal wall, which at this point is formed by the middle constrictor muscle of the pharynx. The anterior and posterior pillars of this region are formed by the palatoglossal and palatopharyngeal folds (Fig. 64-6). These folds are elevations of the mucosa created by the underlying muscles, the palatoglossus and palatopharyngeus. The superior pole of the tonsil rests against the soft palate, whereas the inferior pole is at the inferior border of the middle constrictor muscle. During a tonsillectomy, if the lateral wall or bed of the tonsil is penetrated, the adjacent lateral space or parapharyngeal space is entered.

The inferior pole of the palatine tonsil is of interest because of its relationship to the interval between the middle and inferior constrictor muscles. As already described, the important relationships of this space are the stylopharyngeus muscle, the glossopharyngeal nerve (cranial nerve IX), the lingual artery, and the stylohyoid ligament. Attempts to clamp tonsillar branches of the lingual or facial arteries supplying the inferior pole of the tonsil can jeopardize cranial nerve IX because of its relationship to the inferior pole of the tonsil. The sensory (touch, pain, and taste) distribution of cranial nerve IX is to the posterior portion of the tongue, lateral wall of the oropharynx, and upper portion of the laryngopharynx. Paralysis of cranial nerve IX may produce sufficient loss of sensation to cause the patient to choke during swallowing, since proper reflex control of the upper airway is lost.

Musculature of Soft Palate

The muscles of the soft palate should be considered as part of the pharyngeal muscle group, not only because of their importance in swallowing but also because of the similarity in their innervation and development. With the exception of the tensor veli palatini, which is derived from the mesoderm of the first branchial arch, all other muscles of the soft palate are derived from the fourth through the sixth branchial arch mesoderm.

The soft palate is composed of five muscles: the tensor veli palatini, levator veli palatini, palatoglossus, palatopharyngeus, and uvular. The primary role of the soft palate is closure of the nasopharynx during the second phase of deglutition. It also has an important role in speech.

Deglutition

In 1813 the act of swallowing was divided into three phases by Magendie, a French physiologist (Saunders et al, 1951). These stages are still used to describe the basic events of deglutition. Other reviews of this subject include those of Bosma (1957), Ramsey et al (1955), and Warwick and Williams (1984).

Stage 1

Stage 1 is primarily the movement of the anterior tongue, pressing the bolus of food against the hard palate and initiating the movement of the mass to the posterior part of the tongue and oral cavity. Although the intrinsic tongue muscles are important in this regard, the suprahyoid muscles (digastric, stylohyoid, geniohyoid, and mylohyoid) are particularly required in the movement of solid, as compared with liquid, masses. As the suprahyoid muscles contract, they elevate the hyoid bone directly and the laryngeal apparatus indirectly.

Patients undergoing resection of oral cavity/oropharyngeal neoplasms and reconstruction of the resulting defects frequently experience difficulties with the oral phase of swallowing. Logemann (1983) has shown increased oral transit times for solids and liquids in patients undergoing resections of neoplasms of the anterior and lateral floor of the mouth. Transit times were increased significantly when reconstruction was done with local tissue flaps that tethered the tongue and impaired retropulsion of the bolus.

Komisar (1990) has demonstrated that patients who have undergone mandibular reconstruction have more problems with deglutition and mastication than those patients whose mandibular defects have not been reconstructed. Postoperative scarring, fibrosis, and the loss of masticator muscle mass are all factors that cause impaired swallowing postoperatively. The restoration of anatomic continuity of the mandible, although providing acceptable cosmesis, does not appear to restore normal or, in some cases, even serviceable oral function in deglutition.

Stage 2

Stage 1 is sometimes called the voluntary stage, and stage 2 is called the involuntary stage. As the tongue presses the bolus of food against the soft palate, it is somewhat elevated and tensed by the levator and tensor veli palatini muscles, respectively. At the same time the nasopharynx is effectively sealed, preventing the regurgitation of the food superiorly into the nasopharynx, and the bolus is forced into the oropharynx. A simultaneous narrowing of the fauces or oropharyngeal isthmus is accomplished by the contraction of the palatoglossus and palatopharyngeus muscles. The styloglossus also assists in the complete elevation of the tongue, whereas the stylopharyngeus muscle assists in elevating the pharynx. After entry into the oropharynx, the bolus is propelled downward into the esophagus by the synchronous contraction of the pharyngeal constrictors (Bosma, 1957). An important element of stage 2 is the sealing of the aditus of the larynx. Although this is an active event caused by the action of the muscles associated with the quadrangular membrane (aryepiglotticus, thyroepiglotticus, and thyroarytenoideus), there is some question as to whether the role of the epiglottis is active or passive. Fink (1978) has suggested that the primary mechanism of laryngeal closure by the epiglottis is related to biomechanical forces on the epiglottic cartilage caused by the elevation and abutment of the laryngeal apparatus against the base of the tongue.

Any surgical intervention that interferes with laryngeal elevation or closure will cause dysfunction during stage 2 and will usually result in aspiration. Tracheostomy tethers the larynx in the neck and facilitates aspiration by preventing complete glottic closure. Conservation laryngeal surgery (supraglottic or vertical hemilaryngectomy) also results in aspiration. Patients who have undergone these procedures must relearn the swallowing act. The technique called the supraglottic swallow incorporates a cough following every swallow (Logemann, 1983) followed by another swallow.

Stage 3

Stage 3 is essentially the esophageal phase; it is effected by the peristaltic movement of the esophageal muscle wall. It should be noted that the upper part of the esophagus is composed of striated muscle of branchial arch origin, whereas the lower esophagus is composed of smooth muscle derived from splanchnic mesoderm.

Impairment of the esophageal phase of swallowing is a rare sequela of head and neck surgery. However, tight pharyngeal closure following total laryngectomy can cause severe debilitating strictures. These may require treatment with completion pharyngectomy and pharyngeal reconstruction (de Vries et al, 1990).

Some patients experience dysphagia after either total or partial laryngectomy or resection of oral cavity neoplasms. The role of cricopharyngeal myotomy in this setting has not yet been determined. Currently, multicenter clinical trials are investigating the role of cricopharyngeal myotomy in eliminating dysphagia after head and neck cancer surgery.

Innervation of Muscles of Pharynx and Soft Palate

All of the muscles of the soft palate are supplied by the pharyngeal plexus - with the exception of the tensor veli palatini, which is supplied by the mandibular branch of the trigeminal nerve. The pharyngeal plexus is usually described as composed of cranial nerve IX, X, and XI. Cranial nerve IX provides only motor innervation to the stylopharyngeus. The vagus and the cranial portion of cranial nerve XI carry motor fibers to the superior and middle constrictor muscles as well as to the muscles of the palate via the pharyngeal branch of the vagus. These fibers originate in the nucleus ambiguus, which is a visceral efferent nucleus because the muscles of the pharynx and palate are derived from the branchial arch mesoderm of arches four and six. The inferior constrictor muscle is supplied by the recurrent laryngeal branch of the vagus. The external branch of the pharynx is derived mostly from cranial nerve IX, which supplies the nasopharynx and oropharynx. The laryngopharynx and especially the piriform sinuses receive sensory innervation from the internal laryngeal branch of the superior laryngeal nerve. This was discussed earlier, particularly in relation to local or topical anesthesia for laryngeal biopsy.

Waldeyer's Lymphatic Ring and Tonsils

From the area of the eustachian tube to the base of the tongue the pharyngeal mucosa is infiltrated by diffuse lymphatic tissue and organized lymphatic nodules, which in some areas form specific tonsillar masses. When the pharynx is viewed from its posterior aspect, the aggregate of the subepithelial and submucosal lymphatic tissue, including the tubal, pharyngeal, palatine, and lingual tonsils, forms a ring about the pharyngeal wall, which classically has been called *Waldeyer's lymphatic ring.* It purportedly represents the first line of immunologic defense mechanisms.

In 3% to 4% of patients with metastatic carcinoma in the neck, no primary tumor can be found before initiating therapy. These patients are said to have "occult" or "unknown" priomary tumors. In nearly 50% of these patients, Waldeyer's ring is found to contain a neoplasm initially thought to be "occult" (Batsakis, 1981).

Pharyngeal tonsil

As noted earlier, the pharyngeal tonsil lies at the periphery of the pharyngeal bursa in the nasopharynx. Depending on the size and number of lymphatic nodules, the mucosa can be raised into a substantial mass with intervening folds of the surface epithelium. Such folding contrasts with the crypt type of structure seen in the palatine tonsil. The epithelium consists of the columnar type of pseudostratified cells, although occasionally there are areas of stratified squamous epithelium.

Tubal tonsil

The tubal tonsil is formed primarily by an extension of the lymphatic nodules of the pharyngeal tonsil anteriorly in the mucosa of the lateral nasopharyngeal wall. The nodules are found particularly in the mucosa of the eustachian tube and Rosenmüller's fossa. These areas of lymphatic tissue, even when they are not particularly elevated, are called the *tubal tonsil* (or Gerlach's tonsil).

Palatine tonsils

The palatine tonsils, unlike the other tonsil tissues, are usually large bulbous masses covered by nonkeratinizing stratified squamous epithelium. Histologic sections reveal deep crypts in the surface with abundant lymph follicles underlying the epithelial surface.

Lingual tonsils

Finally, the lingual tonsils are raised circular papilliform masses on the posterior third of the tongue. Each mass usually has a single opening on the mucosal surface that forms a tubular gland or crypt. Mucous glands are frequently described as opening into the crypt, which is lined by stratified squamous epithelium. In histologic sections the crypt contains a cellular detritus, and bacteria can be observed with appropriate staining techniques.

Blood Supply of Tonsils

The blood supply of the palatine tonsil is derived from many sources. These include (1) the ascending palatine artery and tonsillar artery, branches of the facial artery, (2) a branch from the dorsal lingual artery, (3) the ascending pharyngeal artery, and (4) the descending palatine and its branches, the greater and lesser palatine arteries (Fig. 64-7).

The pharyngeal tonsil (adenoids) receives its blood supply from the ascending palatine artery and the ascending pharyngeal artery, derived from the bifurcation of the common carotid artery. The specific blood supply to other tonsil tissues is not significant surgically, since they are only small regional arteries.

Innervation of Tonsils

Innervation of the palatine tonsil is via the greater and lesser palatine branches of the maxillary division of the trigeminal nerve and lingual branches of the glossopharyngeal nerve. The latter are particularly important, comprising the pathway of referred pain to the ear during tonsillitis.

Patients with severe tonsillitis, peritonsillar abscesses, or oropharyngeal tumors often complain of pain in the ear (referred otalgia). The anatomic basis for this phenomenon is that sensory branches of the glossopharyngeal nerve to the oropharynx have their cell bodies located proximally in the inferior ganglion of cranial nerve IX. Also located here are the cell bodies of the tympanic nerve (Jacobson's nerve), which provides general sensation to the medial surface of the tympanic membrane and the middle ear mucosa. Both the oropharyngeal branches and the tympanic nerve project proximally via the trigeminal (cranial nerve V) tract to the ventral posterior medial nucleus of the thalamus. These common central projections account for the simultaneous perceptions of pain in the ear and oropharynx.

Applied Anatomy of Parapharyngeal Region

Many of the anatomic relationships discussed in this chapter are highlighted in Fig. 64-8, a cross-sectional view of the pharynx at the level of the tongue. Whether a surgeon places an incision in the mucosa of the oral cavity or oropharynx because of an elective surgical procedure or is exploring a penetrating oral injury caused by assorted objects, such as knitting needles or sharp sticks, the anatomy beyond the mucosal boundary is hazardous territory. Penetration of the posterior wall causes, in addition to obvious hemorrhage, infection and abscess formation in the retropharyngeal space. Because the inferior limit of this space is the diaphragm, infection may spread inferiorly into the thorax, producing a mediastinitis.

Penetrating oral injuries directed posterolaterally traverse the tonsil bed and the superior constrictor muscle and enter the parapharyngeal space. In this region the structures that can be injured include the internal jugular vein, the internal carotid artery, and nerves associated with the carotid sheath at this point (vagus and hypoglossal nerves and sympathetic trunk). If the penetration is slightly more lateral than the previous example, the parotid can be entered, resulting in injury to any of its contents, the posterior facial vein, the external carotid artery, and one of the trunks of the facial nerve. Finally, more direct lateral penetrations may injure the opening of the parotid duct, or after traversing the buccinator muscle, lacerate the duct more proximally in the cheek tissue.

In addition to deficits caused by surgical or other trauma, the otolaryngologist-head and neck surgeon should be aware of other signs and symptoms in the pharynx caused by pathologic conditions in the parapharyngeal regions. For example, trismus may be the result of peritonsillar space infections causing pterygoid myositis or direct infiltration of the pterygoid muscles by tumor extending out of the pterygoid fossa.

Palatal or pharyngeal hypotonia may be caused by vagus or glossopharyngeal cranial nerve tumors. A mass in the oropharynx/soft palate/tonsillar area may represent the medial extension of a parapharyngeal space tumor or an aberrant internal carotid artery. The clinician must use caution in evaluating patients with masses in the pharynx and augment a careful and complete head and neck examination with appropriate imaging studies before obtaining a biopsy specimen.