Easier to Swallow: Pictorial Review of Structural Findings of the Pharynx at Barium Pharyngography[1]

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ONLINE-ONLY SA-CME

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LEARNING OBJECTIVES

After completing this journal-based SA-CME activity, participants will be able to:

- Identify normal structures of the pharynx that can be seen at air-contrast pharyngography.
- Discuss congenital and nonmalignant abnormalities of the pharynx.
- Describe malignant pharyngeal lesions and their associated expected posttreatment appearances.

TEACHING POINTS
See last page

Barium pharyngography remains an important diagnostic tool in the evaluation of patients with dysphagia. Pharyngography can not only help detect functional abnormalities but also help identify a wide spectrum of structural abnormalities in children and adults. These structural abnormalities may reflect malignant or nonmalignant oropharyngeal, hypopharyngeal, or laryngeal processes that deform or alter normal coated mucosal surfaces. Therefore, an understanding of the normal appearance of the pharynx at contrast material–enhanced imaging is necessary for accurate detection and interpretation of abnormal findings. Congenital malformations are more typically identified in the younger population; inflammatory and infiltrative diseases, trauma, foreign bodies, and laryngeal cysts can be seen in all age groups; and Zenker and Killian-Jamieson diverticula tend to occur in the older population. Squamous cell carcinoma is by far the most common malignant process, with contrast-enhanced imaging findings that depend on tumor location and morphology. Treatments of head and neck cancers include total laryngectomy and radiation therapy, both of which alter normal anatomy. Patients are usually evaluated immediately after laryngectomy to detect complications such as fistulas; later, pharyngography is useful for identifying and characterizing strictures. Deviation from the expected posttreatment appearance, such as irregular narrowing or mucosal nodularity, should prompt direct visualization to evaluate for recurrence. Contrast-enhanced imaging of the pharynx is commonly used in patients who present with dysphagia, and radiologists should be familiar with the barium pharyngographic appearance of the normal pharyngeal anatomy and of some of the processes that alter normal anatomy.

Abbreviation: SCC = squamous cell carcinoma

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Introduction

The pharynx is complex in both anatomy and function, being involved in speech, respiration, and swallowing. Benign and malignant pharyngeal and laryngeal abnormalities can cause a wide variety of symptoms, including dysphagia, odynophagia, and globus sensation. As a result, barium examination of the upper gastrointestinal tract remains a common primary diagnostic tool, with evaluation of the pharynx being an integral component. In addition, endoscopic examination inadequately depicts many portions of the pharynx. Therefore, the ability to detect structural lesions is important for the diagnosis and management of a diverse group of pharyngeal abnormalities.

In this article, we review imaging technique for evaluation of structural lesions of the pharynx. In addition, we describe the normal pharyngeal anatomy and normal variants, as well as the imaging features of a variety of nonmalignant and malignant abnormalities. We also discuss treatment options for head and neck cancer, along with expected posttreatment findings and possible complications.

Imaging Technique

Structural lesions of the pharynx are best imaged using air-contrast technique (1). Patients should refrain from smoking for 12 hours and from eating for at least 4 hours before the examination; a relatively dry pharyngeal surface leads to better mucosal coating. The examination starts with the patient standing. One swallow of high-density barium suspension is observed to evaluate for aspiration, leak, stricture, obstruction, or delayed emptying with the patient in the upright lateral position. Motor function of the pharynx is assessed with the patient standing; swallows are videorecorded in the upright lateral and anteroposterior positions. The patient then takes a swallow of high-density barium suspension to coat the oropharynx and hypopharynx. The patient is instructed to puff out the cheeks as if blowing a trumpet (modified Valsalva maneuver), and a well-collimated lateral view is obtained. Another lateral view is obtained with the patient phonating the letter E (phonation). Anteroposterior views are then obtained with the patient performing the same maneuvers. On the anteroposterior view, the pharynx is best imaged with the patient's head inclined so that the mandible is projected over the occiput (2). Solid-column evaluation may be helpful for evaluation of the inferior aspect of the hypopharynx, since normal cricopharyngeal contraction during both phonation and modified Valsalva maneuvers may mask subtle abnormalities (2).

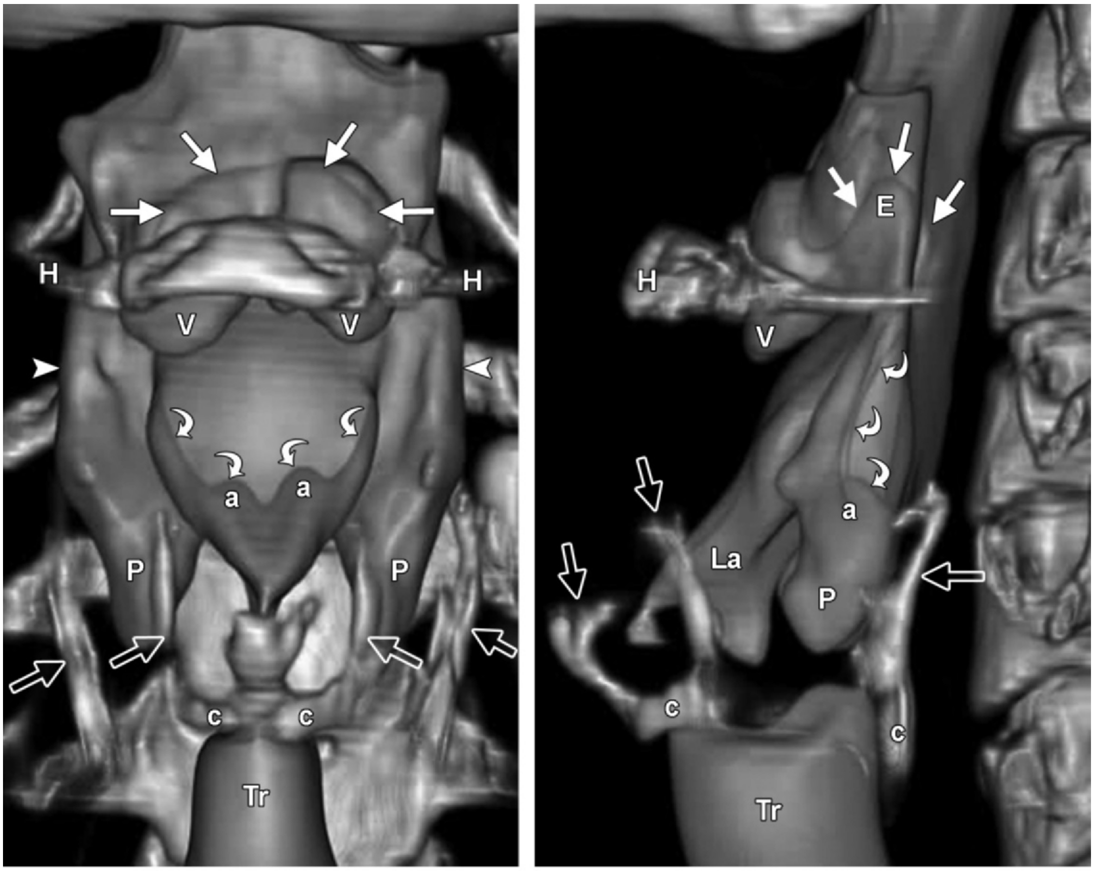
Modified barium swallow studies performed in conjunction with evaluation for speech-related pathologic conditions are currently used for pretreatment assessment of head and neck cancer patients to identify those at risk for swallowing dysfunction and to provide a guide for posttreatment rehabilitation (3).

Normal Anatomy of the Pharynx

The pharynx is anatomically divided into the oropharynx and hypopharynx by the pharyngoepiglottic fold, which is not typically seen at barium pharyngography. Therefore, either the base of the free margin of the epiglottis or the hyoid bone is used as a proxy landmark on static air-contrast images to delineate this boundary (2). The hypopharynx lies posterior and lateral to the laryngeal cartilages.

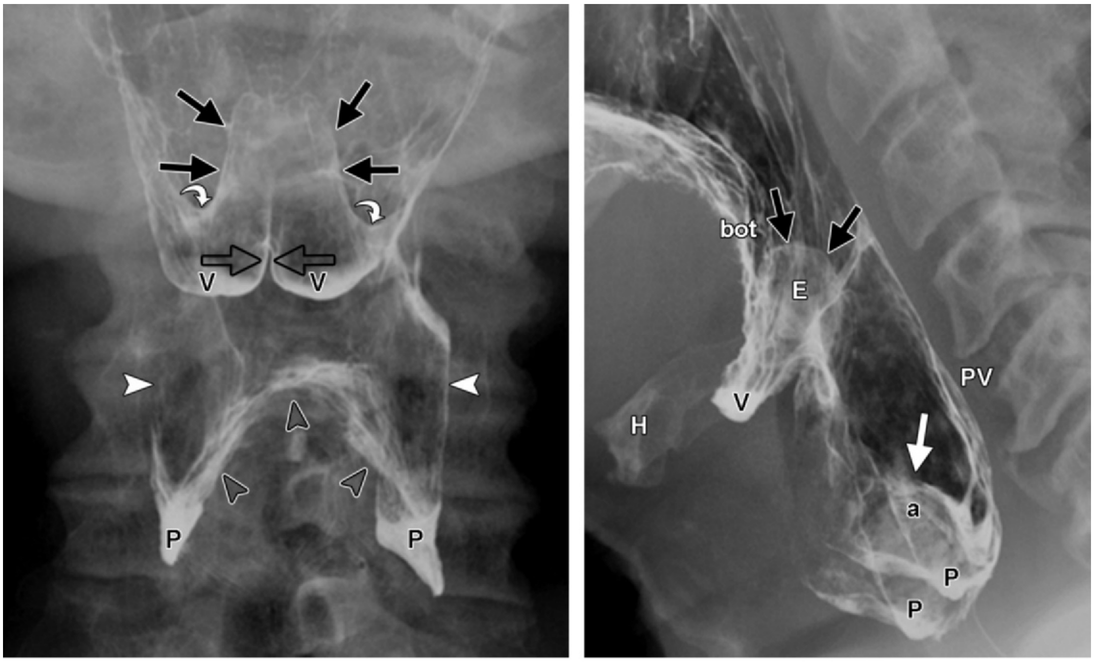
Teaching Point

Anteroposterior images of the pharynx (Figs 1a, 2a) show the valleculae as paired symmetric structures divided by the median glossoepiglottic fold. The free margin of the epiglottis projects superior to the valleculae. The cornua of the hyoid bone project on end; the hyoid bone will change its position relative to the pharynx as it moves during swallowing. The hypopharynx consists of the piriform sinuses, the posterior pharyngeal wall, and the postcricoid region anteriorly (4). The lateral walls of the piriform sinuses are the lateral margins of the hypopharynx. The cricoid cartilage compresses the anterior hypopharyngeal



a. b.

Figure 1. Normal anatomy of the pharynx. **(a)** Anteroposterior three-dimensional reconstructed image from neck computed tomographic (CT) data shows division of the pharynx into the oropharynx (top) and hypopharynx (bottom) near the level of the valleculae *(V)* and hyoid bone *(H)*. The true anatomic division between the oropharynx and hypopharynx is the obliquely coursing mucosal pharyngoepiglottic fold. The free margin (straight solid arrows) of the epiglottis projects superior to the valleculae. The superior one-third of the lateral margin (arrowheads) of the hypopharynx–piriform sinuses *(P)* is not supported by cartilage but is bounded by the thyrohyoid ligament. The inferior two-thirds of the lateral margin is supported by the alae of the thyroid cartilage (open arrows). The aryepiglottic folds (curved arrows) are paired structures that cover the arytenoid cartilages *(a)*. *c* = cricoid cartilage, *Tr* = trachea. **(b)** Lateral three-dimensional reconstructed image from neck CT data shows division of the pharynx into the oropharynx (top) and hypopharynx (bottom) near the level of the valleculae *(V)*. The free margin (solid straight arrows) of the epiglottis *(E)* projects superior to the valleculae. The hypopharynx–piriform sinuses *(P)* are surrounded by the laryngeal cartilages (open arrows) posteriorly. The cricoid cartilage *(c)* compresses the anterior wall of the hypopharynx inferiorly and divides the piriform recesses. The aryepiglottic folds (curved arrows) course posteriorly from the free margin of the epiglottis and then medially and inferiorly to cover the posterior surface of the arytenoid cartilage *(a)*. *H* = hyoid bone, *La* = laryngeal vestibule, *Tr* = trachea.



a. b.

Figure 2. Normal anatomy of the pharynx. **(a)** Anteroposterior air-contrast image shows that the true anatomic dividing line between the oropharynx and hypopharynx is the obliquely coursing pharyngo-epiglottic fold (curved arrows). The vallecular pouches *(V)* are symmetric, divided by the median glossoepiglottic fold (open arrows). The free margin (straight solid arrows) of the epiglottis projects superior to the valleculae. The hypopharynx consists of the piriform sinuses *(P)*, the posterior pharyngeal wall, and the postcricoid region. The lateral wall of the piriform sinus demarcates the lateral margin (solid arrowheads) of the hypopharynx. The entire bulk of the larynx pressing on the anterior pharynx creates a coated mucosal surface known as the "postcricoid line" (open arrowheads). **(b)** On a lateral air-contrast image, the slightly nodular surface of the base of the tongue *(bot)* is superior to the valleculae *(V)*. Although the hyoid bone *(H)* moves and changes its position relative to the pharynx during swallowing, it can be used as a proxy landmark to delineate the dividing line between the oropharynx and hypopharynx. The free margin (black arrows) of the epiglottis *(E)* projects posterior and superior to the vallecula. The aryepiglottic fold (white arrow) covers the posterior surface of the arytenoid cartilage *(a)*. The prevertebral soft tissues *(PV)* lie between the posterior wall of the oropharynx and hypopharynx and the vertebral column. *P* = piriform sinuses.

wall and divides the piriform sinuses inferiorly. The coated mucosal surface (postcricoid line) results from the entire bulk of the larynx pressing on the anterior pharynx and can be traced from the inferior tip of one piriform sinus to the other (2). The aryepiglottic folds are paired symmetric structures that cover the posterior surfaces of the arytenoid cartilages. Laryngeal penetration and aspiration of contrast material will coat the inner surfaces of the laryngeal vestibule; the laryngeal ventricle is often coated as well.

Lateral images of the oropharynx (Figs 1b, 2b) depict the tongue base as a large, smooth, curved structure extending from the mouth to the valleculae. The valleculae are superimposed on the tongue base and appear as a barium-containing pouch posteroinferior to it. The free margin of the epiglottis projects posterior and superior to the valleculae and is a straight or slightly curved structure. Upon phonation, the oropharynx widens, the tongue moves anteriorly, and the valleculae deepen (2).

On lateral views of the hypopharynx, the piriform sinuses and aryepiglottic folds are superimposed. The coated anterior walls of the piriform sinuses are the most anterior structures of the hypopharynx. The aryepiglottic folds extend posteroinferiorly from the free margin of the epiglottis to cover the posterior surface of the arytenoid cartilages (2). Laryngeal penetration and aspiration of contrast material will result in coating of the anterior wall of the laryngeal vestibule.

Figure 3. Lateral protrusion of the lateral hypopharyngeal walls. Anteroposterior image from an air-contrast barium study of the pharynx demonstrates lateral protrusion of the superior one-third of the lateral walls of the piriform sinuses (arrowheads). This phenomenon is more commonly seen in elderly patients, in whom the supporting thyrohyoid membrane is weakened, and becomes more pronounced with increased pharyngeal pressure during performance of a modified Valsalva maneuver.

Figure 4. Lymphoid hyperplasia. Anteroposterior image from an air-contrast barium study of the pharynx demonstrates multiple small nodules within the vallecular pouches (arrows), a finding consistent with lymphoid hyperplasia.

Normal Variants

Artifacts arise from failure to coat one or more mucosal surfaces. Artifactual mucosal surface irregularities may be produced by retained mucus or particulate material in the pharynx. Pharyngeal weakness, or the inability to perform the Valsalva maneuver or phonation, leads to coaptation of one surface with another, which may mimic a pharyngeal mass (1,2).

Lateral protrusion of the lateral wall of the hypopharynx is due to weakening of the thyrohyoid membrane, which supports the superior one-third of the lateral wall of the piriform sinus, in combination with relative increased pharyngeal pressure (Fig 3). The thyrohyoid membrane is weakened in elderly patients (and in some younger patients with chronically elevated pharyngeal pressures, such as glassblowers or trumpet players), and protrusion of the lateral walls becomes more pronounced with a modified Valsalva maneuver (2,5). The inferior two-thirds of the lateral wall of the piriform sinus is not affected, since it is supported laterally by the alae of the thyroid cartilage. If the lateral pharyngeal pouches attain a size that allows postdeglutition retention of food and liquid, penetration and aspiration may occur (6).

Normal *lymphoid follicles* can be seen at the tongue base and within the valleculae (Fig 4). Lymphoid tissue at these sites causes surface mucosal nodularity. Mild asymmetry of the vallecular pouches due to lymphoid tissue is a normal variant.

Structural abnormalities of the pharynx are diagnosed by detecting a change in the normal coated surfaces or an alteration in density.

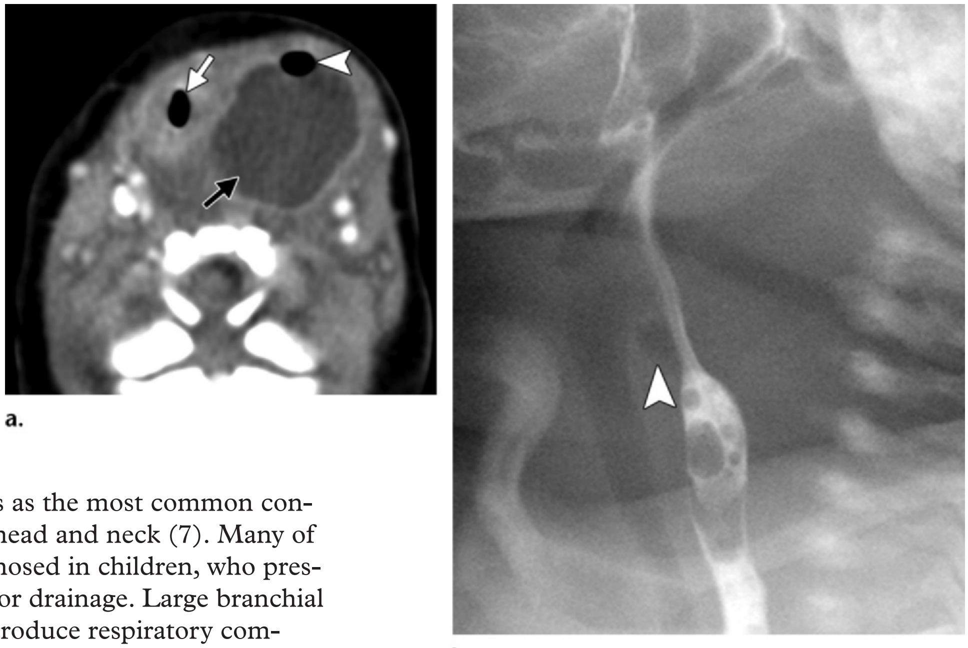
Teaching Point

Nonmalignant Abnormalities

A wide range of nonmalignant abnormalities can be detected at barium pharyngography in both pediatric and adult patients. In the pediatric population, branchial arch anomalies, laryngeal clefts, and tracheoesophageal fistula are examples of detectable abnormalities. Foreign bodies, perforation, infectious or inflammatory processes, and laryngeal cysts can be seen in both pediatric and adult patients. Zenker and Killian-Jamieson diverticula tend to be seen more frequently in the adult population.

Congenital malformations occur rarely and include second and third *branchial arch anomalies*. These anomalies are second only to thyroglossal

Figure 5. Third branchial cleft cyst. **(a)** Axial CT image obtained in a 1-week-old female neonate shows a large, fluid-attenuation parapharyngeal mass (black arrow) containing gas (arrowhead) in the left side of the neck. The mass has caused the trachea (white arrow) to deviate to the right. **(b)** Oblique image from a water-soluble contrast material–enhanced swallow study shows a cystic cavity (arrowhead) in the left side of the neck that did not fill with contrast material despite the patient's being placed in various positions. A third branchial cleft cyst was excised at surgery.



a. b.

duct cysts and sinuses as the most common congenital lesions in the head and neck (7). Many of these lesions are diagnosed in children, who present with a neck mass or drainage. Large branchial arch anomalies may produce respiratory compromise or dysphagia. All such anomalies result from incomplete obliteration of pharyngeal clefts and pouches during embryogenesis; they may manifest as a cyst, sinus, or fistula (7). In patients suspected of having second and third branchial arch anomalies, barium pharyngography can be performed for localization of a fistulous tract (7). Second branchial arch anomalies are the most common of all branchial arch anomalies (7). They exit the pharynx at the level of the tonsillar fossa. Third branchial arch anomalies exit the pharynx at the piriform sinus (Fig 5) (7). Branchial arch anomalies are treated with complete surgical excision. They have a high incidence of infection if unresected and of recurrence if incompletely resected.

Laryngeal clefts are rare (8). They result from a lack of separation between the laryngotracheal and pharyngoesophageal systems due to failure of fusion of the posterior cricoid lamina, thus allowing a sagittal communication between the trachea and esophagus (8,9). Classification of laryngeal clefts is based on the downward extent of the cleft, ranging from a submucosal interarytenoid cleft to a cleft that extends into the thoracic trachea (9). Patients typically present with swallowing difficulty, stridor, recurrent pneumonia, or weak cry. The majority of patients with laryngeal clefts have other congenital anomalies, most commonly gastrointestinal anomalies such as esophageal atresia or imperforate anus. Several syndromes are also associated with laryngeal clefts, such as CHARGE syndrome and VACTERL (VATER) association (8). Definitive diagnosis is made with endoscopic visualization (9). However, many of these patients are referred for barium esophagography owing to clinical suspicion for tracheoesophageal fistula. At contrast-enhanced imaging, both the esophagus and the trachea are opacified due to communication between the pharynx and larynx (Fig 6) (8). Management depends on symptom severity; the most severe cases require open repair.

Although located distal to the pharynx, *tracheoesophageal fistula* is another congenital abnormality to consider when evaluating infants with feeding difficulties. Congenital tracheoesophageal fistula can occur with or without associated esophageal atresia; the majority of patients have both abnormalities. Tracheoesophageal fistula is also commonly associated with other congeni-

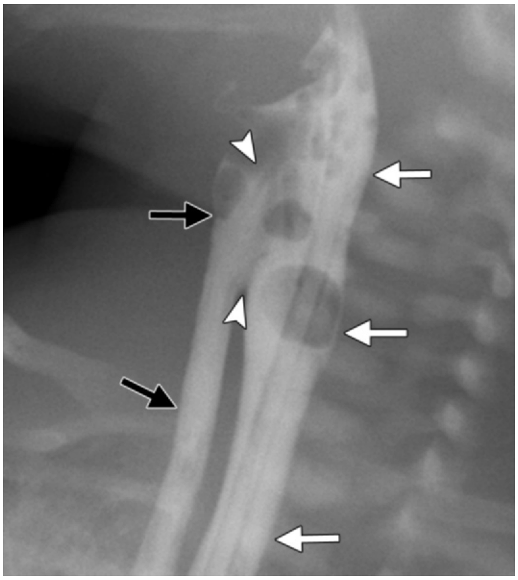


Figure 6. Laryngeal cleft in a 5-day-old male neonate with ambiguous genitalia and imperforate anus who was evaluated for tracheoesophageal fistula because of increasing congestion during feeding. Oblique image from a barium swallow study shows filling of the esophagus (white arrows) and airway (black arrows) with contrast material due to a cleft (arrowheads) between the pharynx and larynx. Results of bronchoscopy confirmed the presence of a type III posterior laryngeal cleft that extended from the cricoid cartilage to the proximal trachea.

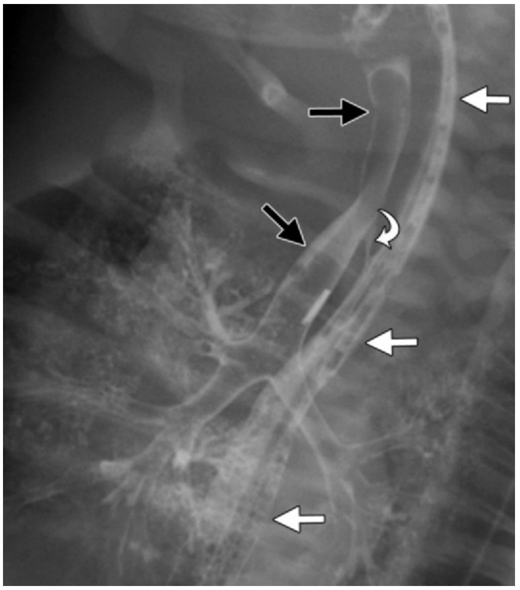


Figure 7. Tracheoesophageal fistula in a 1-month-old male infant with aortic coarctation and ventricular septal defect who developed bradycardia and coughing during feeding. Oblique image from a swallow study shows contrast material filling the esophagus (straight white arrows) and airway (black arrows) after a few swallows. A fistulous connection (curved arrow) at the T2 level between the esophagus and trachea is also present, a finding consistent with an H-type tracheoesophageal fistula.

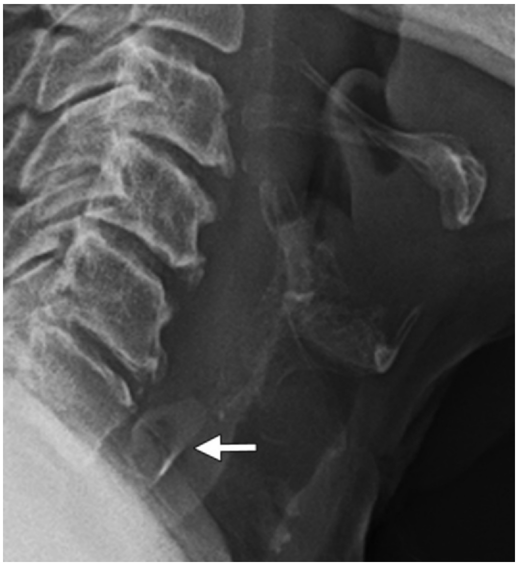
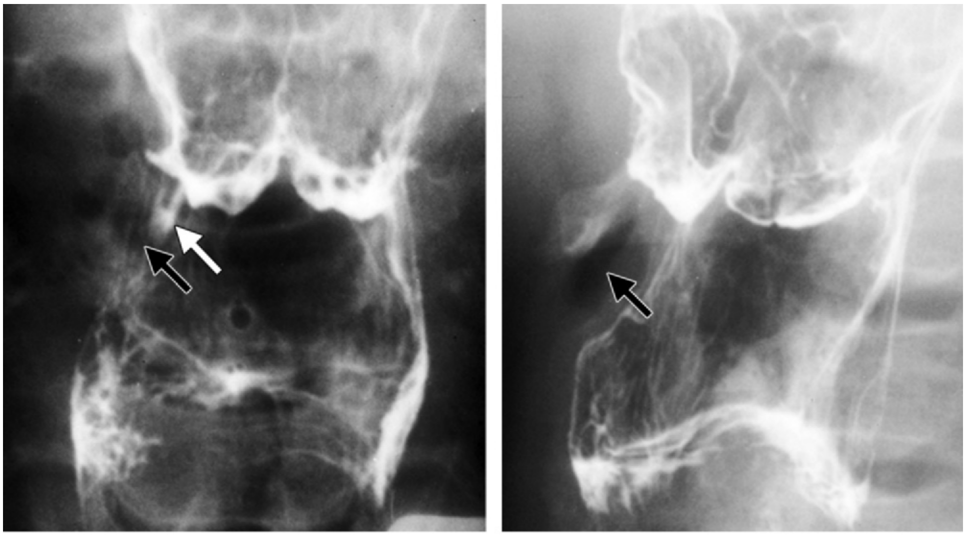


Figure 8. Ingested foreign body near the cricopharyngeus muscle in an 83-year-old woman with odynophagia after eating chicken. Lateral conventional radiograph of the neck shows a radiopaque foreign body (arrow) anterior to the C6 and C7 vertebral bodies. Upper gastrointestinal endoscopy revealed a bone fragment within the proximal esophagus just distal to the upper esophageal sphincter.

tal anomalies such as cardiac and genitourinary anomalies and with genetic syndromes (10). Esophageal atresia and tracheoesophageal fistula require surgical repair (10,11). Typical features at contrast-enhanced imaging include opacification of both the esophagus and trachea and demonstration of a fistulous connection between the two structures (Fig 7).

Ingestion of *foreign bodies* occurs at all ages (Fig 8). Coins are the most commonly ingested radiopaque foreign bodies in children (12). The majority of ingested foreign bodies are lodged at the thoracic inlet. Symptoms include pain, excessive salivation, cough, difficulty breathing, nausea, and vomiting. The imaging appearance depends on the composition and shape of the ingested object. Swallow studies may reveal the presence of a radiolucent foreign body (13). Most foreign bodies are amenable to endoscopic removal (12).

Pharyngeal perforation is uncommon. The most common cause of pharyngeal perforation is iatrogenic, usually instrumentation (eg, intubation, nasogastric tube placement, or endoscopy) (14). Additional causes include trauma,



a. b.

Figure 9. Right vallecular perforation from chicken bone ingestion. **(a)** Anteroposterior image from an air-contrast barium study of the pharynx demonstrates a small amount of contrast material (white arrow) leaking from the right vallecula, and a gas collection (black arrow) beneath the hyoid bone. **(b)** Oblique image demonstrates the small gas collection (arrow) beneath the hyoid bone.

foreign bodies (Fig 9), spontaneous perforation, and emesis. Contrast-enhanced imaging demonstrates leakage of contrast material from the perforation site. The majority of cases can be managed conservatively (14).

Infectious or inflammatory processes of the pharynx are usually characterized by smooth thickening and enlargement of the pharyngeal structures due to diffuse inflammation or infiltration of the submucosa (2). Causes include infections (epiglottitis and pharyngitis), granulomatous diseases (tuberculosis and sarcoidosis), amyloidosis, and therapeutic irradiation.

Epiglottitis (also known as supraglottitis) is characterized by edema of the supraglottic structures and is usually caused by bacterial infection (15). It is a disease that affects both children and adults and may be fatal if not rapidly diagnosed. Since the introduction of *Haemophilus influenzae* type B vaccine in 1988, the incidence, demographics, and causative pathogens of epiglottitis have changed. The incidence in children has decreased, with more cases now occurring in adults. Although *H influenzae* type B is still a causative pathogen in the postvaccine era, it is common to see other pathogens such as *Streptococcus pneumoniae* and *S pyogenes* (16).

Uncomplicated pharyngitis from bacterial or viral infection usually results in a minimally detectable abnormality at barium pharyngography, and patients are rarely referred for evaluation. However, pharyngitis can result in retropharyngeal abscess formation. Imaging demonstrates that retropharyngeal abscesses widen the prevertebral soft-tissue stripe (Fig 10). Retropharyngeal

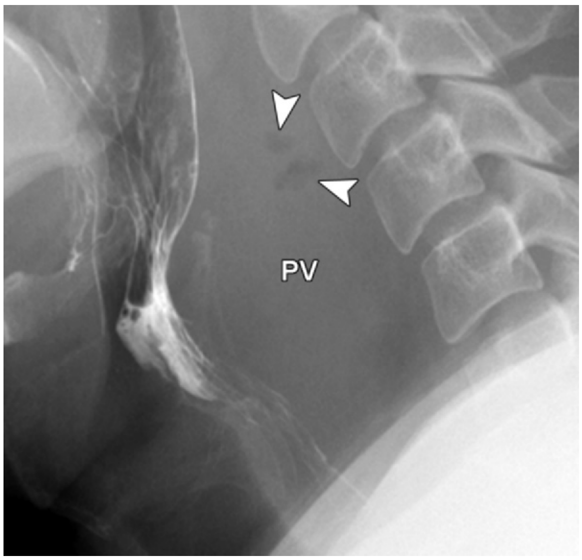
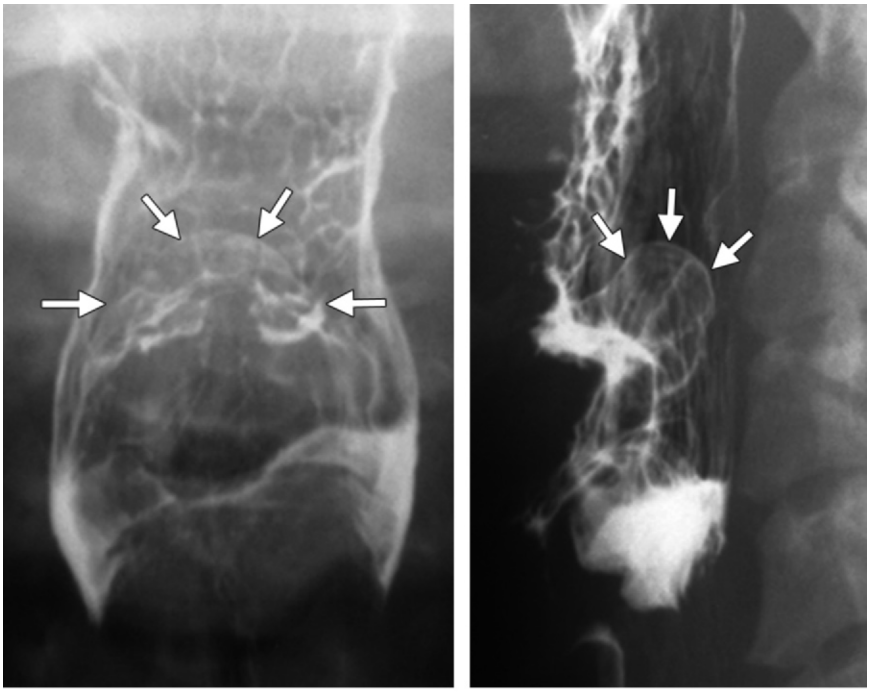


Figure 10. Retropharyngeal abscess in a 30-year-old man who presented with worsening odynophagia and dysphagia. Lateral image from a barium pharyngographic study demonstrates marked widening of the prevertebral soft-tissue stripe *(PV)* caused by a soft-tissue mass containing small foci of gas (arrowheads).



a. b.

Figure 11. Pharyngeal sarcoidosis. Anteroposterior **(a)** and lateral **(b)** images from an air-contrast barium study of the pharynx demonstrate smooth enlargement of the epiglottis (arrows). Sarcoidosis affects the supraglottic structures and is characterized by smooth thickening and diffuse enlargement of the epiglottis and aryepiglottic folds.

abscesses can occur as a result of trauma or of direct or lymphatic spread from infections of the ear, nose, or throat (17). Treatment of retropharyngeal abscesses requires antibiotics and surgical drainage (18). If untreated, the abscess may spontaneously rupture, resulting in aspiration of purulent material. Airway compromise due to narrowing of the oropharyngeal airway may also occur if the abscess if not surgically drained.

Granulomatous diseases are not often seen but most commonly affect the supraglottic structures. Smooth, symmetric enlargement of the epiglottis and aryepiglottic folds is the characteristic abnormality at pharyngography. Tuberculosis is the granulomatous disease that most commonly involves the pharynx (19), although cases of sarcoidosis have also been reported. The caseating granulomas that characterize tuberculosis may produce large areas of ulceration. Sarcoidosis is a multisystemic disease characterized by noncaseating granulomas. Pharyngeal involvement is seen in 3%–5% of patients, with or without pulmonary involvement, and most commonly affects the supraglottic structures (19,20). Pharyngeal sarcoidosis is characterized by smooth thickening and enlargement of the supraglottic structures (Fig 11) (2).

Amyloidosis is a systemic or localized disease characterized by extracellular infiltration and deposition of fibrillar proteins in various tissues, resulting in enlargement of pharyngeal structures (21). Head and neck involvement is seen in 12%–90% of cases and is usually localized or solitary (19).

Laryngeal cysts are usually benign and may be congenital or acquired. These cysts can be diagnosed at any age but are most common in patients in the 6th decade of life (22). Presenting symptoms include dysphonia, airway obstruction, and foreign body sensation in the throat. One classification system categorizes laryngeal cysts into ductal and saccular types (23). Ductal cysts result from submucosal gland duct obstruction and represent the majority of laryngeal cysts. The valleculae, vocal cords, and epiglottis (Fig 12) are most commonly involved.

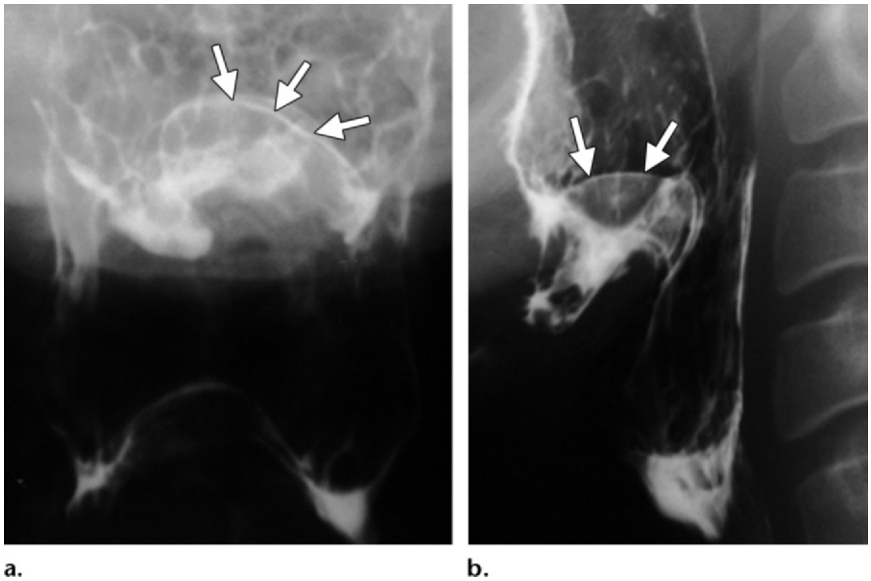


Figure 12. Epiglottic cyst. **(a)** Anteroposterior image from an air-contrast barium study of the pharynx demonstrates the superior border of a smooth mass (arrows) projecting over the epiglottis. **(b)** Lateral image shows the smoothly marginated mass (arrows) anterior to the epiglottis and filling the left vallecular pouch.

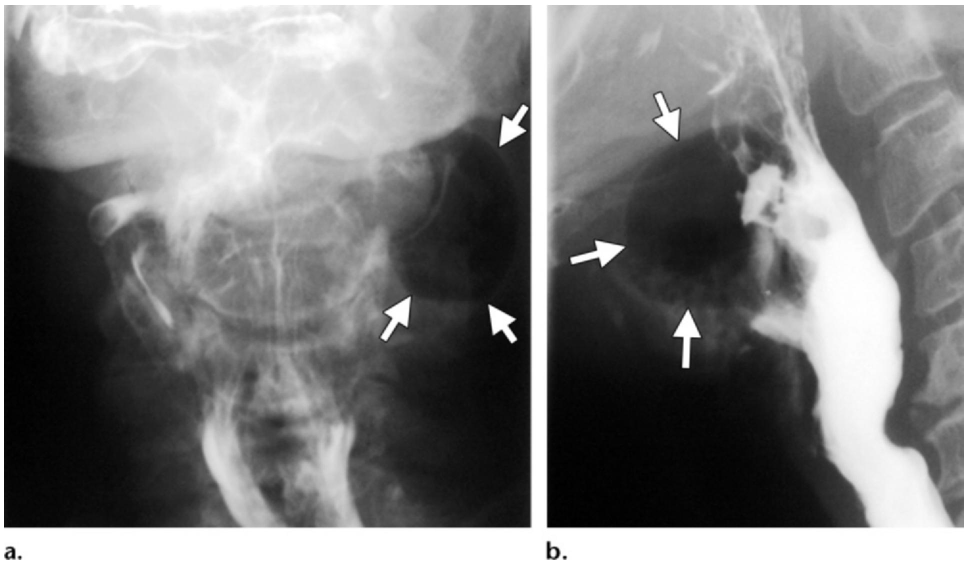
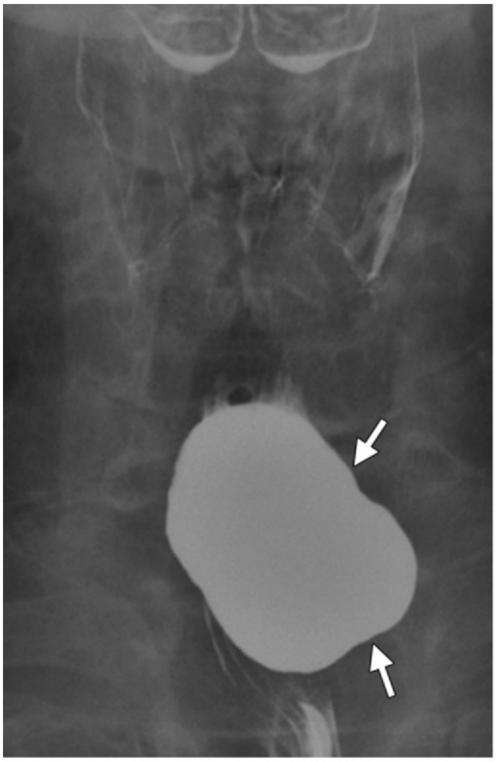


Figure 13. External laryngocele. **(a)** Anteroposterior image from a barium pharyngogram demonstrates an air-filled structure in the left side of the neck (arrows) that is lateral to the pharyngeal structures. **(b)** Lateral image shows an air-filled external laryngocele (arrows) located anterior to the pharynx and just inferior to the mandible.

Saccular cysts result from mucus retention within the laryngeal saccule from obstruction or loss of patency of the saccular orifice (24). The laryngeal saccule, a blind-ending pouch containing mucous glands, arises from the anterior part of the laryngeal ventricle and extends superiorly between the false vocal cord and the inner surface of the thyroid cartilage (25). Saccular cysts are classified as anterior or lateral depending on their location. Lateral saccular cysts may be acquired. A laryngocele is a saccular cyst that contains air and that maintains communication with the laryngeal lumen (25,26). Laryngoceles are classified as internal, external, or a combination thereof based on their relationship with the thyrohyoid membrane. An internal laryngocele remains confined within the larynx between the false vocal cord and the medial surface of the thyrohyoid membrane. An external laryngocele extends upward and protrudes laterally through the thyrohyoid membrane (Fig 13). A "combined" laryngocele contains dilated internal and external components (26,27). Saccular cysts and laryngoceles are associated with laryngeal cancer, and these patients should be evaluated accordingly.

Teaching Point



a.

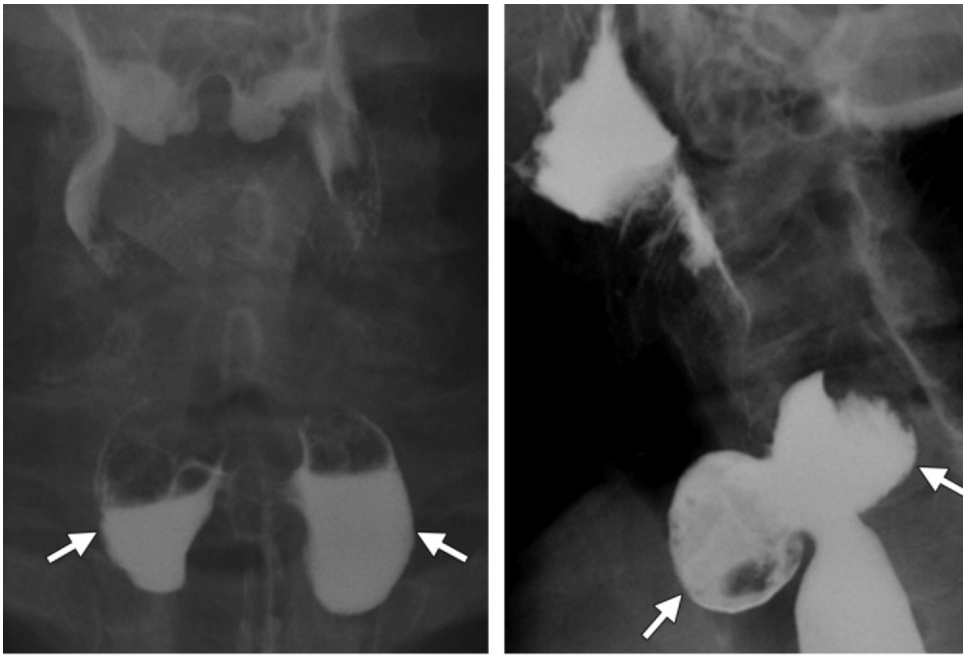
b.

c.

Figure 14. Zenker diverticulum and repair. **(a, b)** Anteroposterior **(a)** and lateral **(b)** images from a barium swallow study performed in a 73-year-old woman with a 3-year history of dysphagia and regurgitation demonstrate a diverticulum in the midline and extending posteriorly (arrows), a finding consistent with a Zenker diverticulum. **(c)** Lateral image from a barium pharyngogram obtained in a 71-year-old woman who had undergone cricopharyngeal myotomy and tacking of a Zenker diverticulum to the prevertebral fascia shows a small amount of contrast material in the diverticular remnant (arrow), which has been surgically inverted to facilitate food emptying.

At imaging, laryngeal cysts appear as smoothly hemispheric masses that may or may not deform coated surfaces of the pharynx (2). Treatments for laryngeal cysts include open or endoscopic resection and transoral excision (27).

Zenker diverticula are the most common diverticula of the upper gastrointestinal tract. The dehiscence of Killian is an anatomic weak point between the oblique and transverse fibers of the cricopharyngeus; the diverticulum represents herniation of pharyngeal mucosa through this dehiscence (28). Zenker diverticulum is most common in patients in the 7th and 8th decades of life; it is rarely seen in patients less than 40 years of age (29). Symptoms include dysphagia, regurgitation of undigested food, chronic cough, halitosis, and weight loss. However, not all Zenker diverticula are symptomatic. At barium pharyngography, Zenker diverticula are usually located in the midline or slightly to the left of midline on anteroposterior images and extend posteriorly and inferiorly on lateral images (Fig 14) (2). The exact cause of Zenker diverticula is



a. b.

Figure 15. Bilateral Killian-Jamieson diverticula in a 76-year-old woman who presented with nausea and vomiting. Anteroposterior **(a)** and oblique **(b)** images from an upper gastrointestinal study show pooling of contrast material in two diverticula (arrows), which are located laterally and project over the proximal cervical esophagus.

still unclear, but most theories revolve around the formation of a pulsion diverticulum from increased pharyngeal pressure due to structural or functional abnormality of the cricopharyngeus. Accordingly, current treatments for symptomatic Zenker diverticula such as open or endoscopic diverticulectomy or diverticulopexy also include cricopharyngeal myotomy (28,30).

Killian-Jamieson diverticula are rare. They protrude through a muscular gap in the anterolateral wall of the proximal cervical esophagus inferior to the cricopharyngeus. This muscular gap is termed the Killian-Jamieson triangle (31,32). Killian-Jamieson diverticula are bilateral in about 25% of cases (Fig 15) (33) and tend to occur over the same age distribution as Zenker diverticula. Killian-Jamieson diverticula are currently believed to result from relative sidewall weakness in the setting of retrograde reflux pressure against a tight cricopharyngeal sphincter (31). However, virtually all Killian-Jamieson diverticula are asymptomatic and do not require surgical treatment. Because of their rarity, few reports regarding their treatment are available. Reported treatment options include diverticulotomy or diverticulectomy with or without esophagomyotomy (31).

Malignant Abnormalities

More than 90% of malignant lesions in the head and neck are squamous cell carcinomas (SCCs). Less common malignancies include lymphoma, salivary gland tumors, melanoma, Kaposi sarcoma, metastatic disease, and hemangiopericytoma (2). Findings at barium pharyngography depend on tumor location and morphology. Large exophytic tumors prevent normal coating and displace coated mucosal surfaces. Infiltrating tumors tend to demonstrate ulceration.

Teaching Point

Although oropharyngeal and laryngeal SCCs are typically diagnosed at physical examination, certain regions of the pharynx are difficult for the otolaryngologist to visualize. Some patients with dysphagia may also be initially referred for pharyngography rather than otolaryngologic examination. Therefore, it remains important for radiologists to recognize structural abnormalities when performing these studies.

a. b.

Figure 16. Left tonsillar SCC. **(a)** Anteroposterior image from a barium pharyngographic study shows a large mass (arrows) arising from the left tonsillar fossa, filling and distorting the left vallecular pouch *(V)*. **(b)** Lateral image shows the mass (arrows) projecting over the tongue base.

Head and neck SCC is strongly associated with prolonged tobacco and alcohol use (4,34). The increasing incidence of oropharyngeal SCC in younger patients is linked with human papillomavirus infection (35). Current treatments involve surgeries that emphasize voice and swallowing preservation or restoration, chemotherapy, and radiation therapy, either individually or in combination (36).

Oropharynx

Cancers of the *tongue base* are clinically distinct from and generally more aggressive than cancers of the oral tongue, and patients often present at an advanced stage with cervical and distant metastasis (4). The most common presenting symptom of tongue base cancers is persistent sore throat. These tumors tend to infiltrate deeply into the intrinsic muscles of the tongue and into surrounding structures. Ulceration is a common finding.

The *tonsillar complex* consists of the tonsillar fossa and tonsillar pillars. These are the most common sites of SCC of the oropharynx, accounting for 75%–80% of cases (4). Patients are typically asymptomatic initially, but the majority present with odynophagia or dysphagia. Other symptoms include otalgia and bleeding. Tonsillar SCC often involves the anterior tonsillar pillar. Well-differentiated tumors tend to be exophytic, and the coated nodular surface of the tumor is easily detected at barium pharyngography on both anteroposterior and lateral views (Fig 16). Poorly differentiated tumors ulcerate into the pharyngeal wall.

Tumors of the v*alleculae* are generally considered to have a very poor prognosis. Most patients have nodal metastasis and tumor invasion of the tongue base or of the lingual surface of the epiglottis at the time of presentation. Vallecular tumors are extensive, irregular, and ulcerated, and thus are easily differentiated from normal vallecular lymphoid tissue.

Primary *pharyngeal wall* tumors are rare and often manifest at late stages. They remain clinically silent until they become large. Pharyngeal wall tumors often invade the retropharyngeal and prevertebral spaces and extend superiorly into the nasopharynx or inferiorly into the hypopharynx (4). Patients most commonly present with dysphagia and odynophagia. At barium pharyngography, these tumors are large and nodular; deep ulceration is rare.

Larynx

The larynx is divided into three compartments: supraglottis, glottis, and subglottis. Laryngeal cancer most commonly arises in the glottis, followed by the supraglottis; subglottic cancer is rare (37). Bulky exophytic laryngeal tumors are easily identified because they are seen to distort, obliterate, or displace normally coated surfaces at barium pharyngography.

The *supraglottis* extends from the epiglottis and laryngeal surface of the aryepiglottic folds, through the laryngeal ventricle, and inferiorly to the superior surface of the true vocal cords. It includes the epiglottis, laryngeal surface of the aryepiglottic folds, arytenoids, and false vocal cords (38). Patients with supraglottic tumors (Fig 17) typically present with hoarseness or change in voice, persistent sore throat, odynophagia, otalgia, or a neck mass.

The *glottis* consists of the true vocal cords and the anterior and posterior commissures. Glottic tumors are usually diagnosed at an early stage owing to patient hoarseness.

The *subglottis* extends from the inferior surface of the true vocal cords to the inferior aspect of the cricoid cartilage; this region is difficult to visualize at otolaryngologic examination. Subglottic tumors are initially clinically silent, and presenting symptoms are usually secondary to tumor spread.

Hypopharynx

The hypopharynx is divided into three areas: the piriform sinus, the postcricoid region, and the pharyngeal wall. Contrast-enhanced evaluation of the hypopharynx with barium is valuable, since

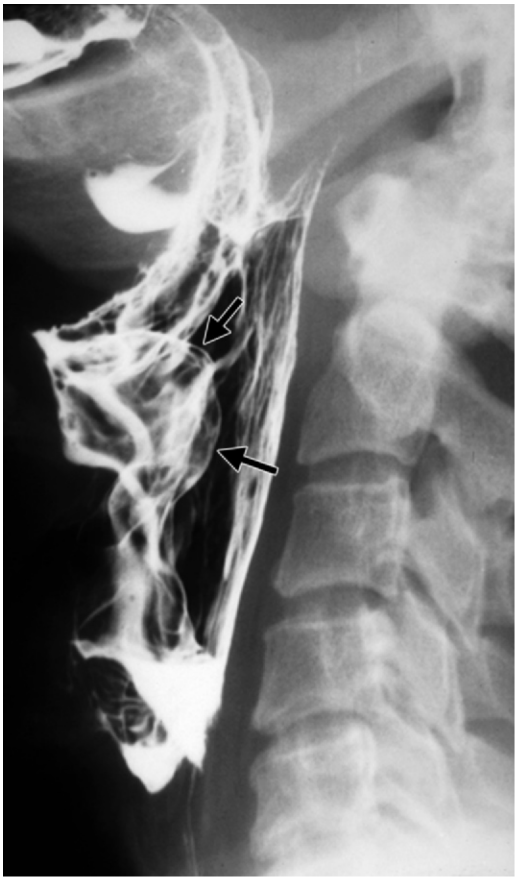


Figure 17. Epiglottic SCC. Lateral image from an air-contrast barium pharyngogram demonstrates marked enlargement of the epiglottis as well as surface nodularity, particularly on its posterior surface (arrows).

hypopharyngeal tumors must attain a significant size to cause symptoms or interfere with swallowing. Patients present with persistent sore throat, dysphagia, hoarseness, otalgia, or a neck mass (4). In addition to tobacco and alcohol use, chronic reflux disease is also a risk factor (39).

The *piriform sinus* is the most common site of hypopharyngeal cancer. Piriform sinus tumors obscure one or both walls of the piriform recess or prevent filling of the involved piriform sinus (Fig 18).

The *postcricoid region* is posterior to the arytenoid cartilages and cricoid ring and extends inferiorly to the pharyngoesophageal junction. Patients with Plummer-Vinson (or Paterson-

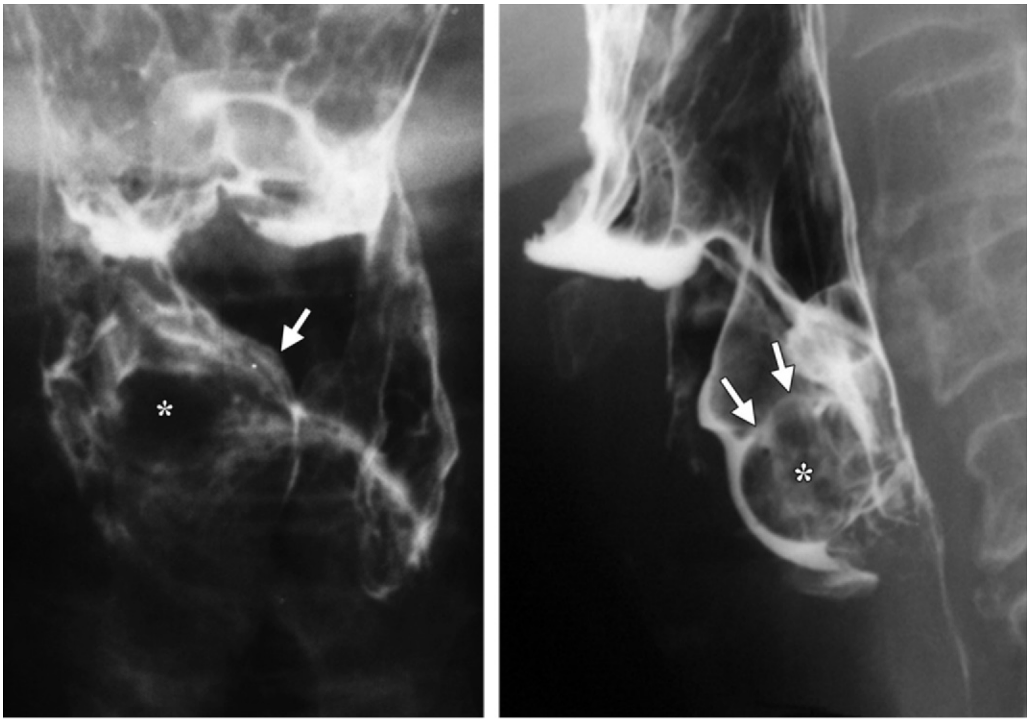


Figure 18. SCC of the right piriform sinus in a patient who presented with hoarseness and odynophagia. **(a)** Anteroposterior image from an air-contrast barium pharyngogram shows a mass in the right piriform sinus (*) displacing the right aryepiglottic fold (arrow) superomedially. **(b)** Lateral image demonstrates a round mass (*) filling the right piriform sinus. The superior surface of the mass (arrows) projects over the hypopharynx.

Figure 19. Postcricoid SCC. Anteroposterior image from an air-contrast barium pharyngogram shows nodularity of the left postcricoid line (arrows), a finding that indicates the presence of tumor.

Kelly) syndrome classically present with the triad of dysphagia, iron-deficiency anemia, and esophageal webs and are at high risk for developing postcricoid cancer (39,40). Postcricoid tumors cause irregular mass effects with associated ulceration (Fig 19).

The posterior *pharyngeal wall* of the hypopharynx extends from the level of the hyoid bone to the pharyngoesophageal junction. At clinical examination, posterior pharyngeal wall tumors of the hypopharynx appear similar to posterior pharyngeal wall tumors of the oropharynx and are often large and nodular. However, hypopharyngeal wall tumors have a slightly worse prognosis. They often invade the retropharyngeal space and can extend superiorly into the nasopharynx and inferiorly into the cervical esophagus.

Patients with head and neck cancer are at risk for developing second primary tumors of the entire aerodigestive tract, either simultaneously or

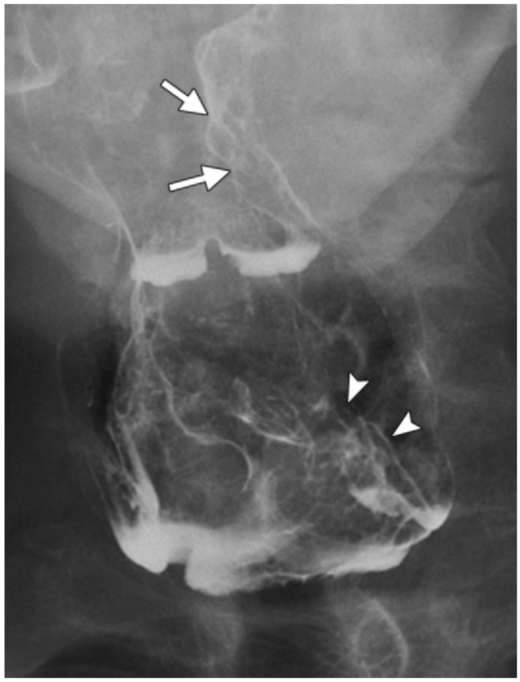


Figure 20. Tonsillar and hypopharyngeal SCC in a 62-year-old man with worsening dysphagia and an enlarging left-sided neck mass. Anteroposterior image from an air-contrast barium pharyngogram shows distortion of the piriform sinuses due to a large mass with a nodular margin (arrowheads). There is medial deviation and nodularity of the coated surface (arrows) of the left tonsillar fossa. Endoscopy revealed a large fungating mass arising from the left tonsil and a separate posterior hypopharyngeal wall mass pressing on the epiglottis.

Figure 21. Appearance of the pharynx after a full course of radiation therapy. **(a)** Anteroposterior image from an air-contrast barium pharyngogram shows smooth, diffuse, symmetric enlargement of the pharyngeal structures. **(b)** Lateral image shows thickening of the epiglottis (solid arrows), penetration of barium into the vestibule and laryngeal ventricle (arrowheads), and aspiration of barium into the trachea (open arrows).

subsequently, since these organs have all been exposed to the same carcinogens (Fig 20) (41). This risk remains high even after long-term follow-up. Most second primary tumors occur in the upper aerodigestive tract, lung, and esophagus (42). Patients who develop second primary tumors have a worse prognosis than patients who do not; the worst prognosis is in patients with second primary tumors of the lung (43).

Radiation Therapy

Radiation therapy plays a crucial role in the treatment of head and neck cancers, either as defini-

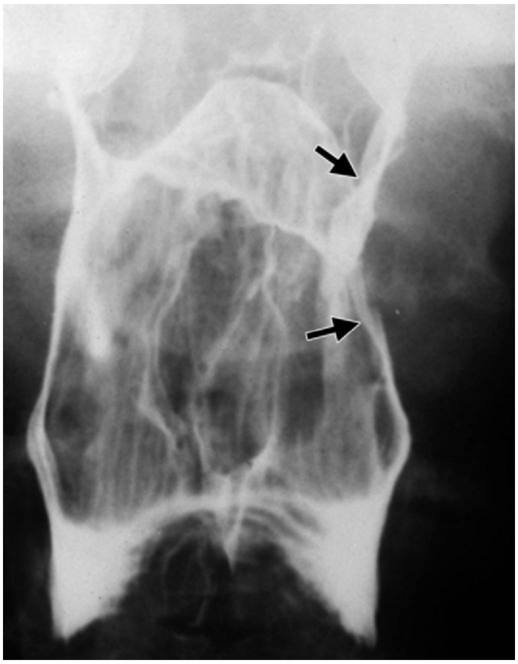


Figure 22. Lymph node recurrence after radiation therapy. Anteroposterior image from an air-contrast barium pharyngogram shows an extrapharyngeal mass (arrows) distorting the lateral wall of the left vallecula and piriform sinus. The mass proved to be recurrent SCC in a left jugulodigastric lymph node.

tive treatment or in combination with surgery and chemotherapy as part of a multidisciplinary approach (37). Radiation-induced edema peaks 6–8 weeks after initiation of therapy and typically subsides within the first 6 months after completion of therapy. Persistent edema may indicate radiation-induced fibrosis in chronically inflamed tissue, or it may be a sign of tumor recurrence or persistence. Complications of radiation therapy include osteochondronecrosis, dysphagia, fibrosis, and strictures (37).

After radiation therapy, the pharyngeal structures within the radiation port are diffusely, smoothly, and symmetrically edematous (Fig 21a) (2). The mucosa overlying the arytenoid cartilage is often markedly edematous. Mild asymmetry may occur if swelling is more pronounced on the side of the original tumor. Motility is often reduced, particularly that of the epiglottis, which contributes to laryngeal penetration and aspiration of contrast material during pharyngography (Fig 21b).

Postirradiation stricture is characterized by persistent symmetric narrowing. Asymmetric thickening along with ulceration or irregularity suggests recurrent or persistent tumor (Fig 22) (2).

Total Laryngectomy

Total laryngectomy continues to play an important role in the treatment of *(a)* advanced laryngeal cancer that is not amenable to conservation laryngeal surgeries, and *(b)* recurrent or persistent laryngeal cancer after failed attempts at organ preservation (44). Total laryngectomy is also the most common surgical procedure for hypopharyngeal cancers, in combination with partial or total pharyngectomy (4,45). Postcricoid tumors almost always require laryngectomy (4).

Total laryngectomy involves removal of the hyoid bone, cartilaginous framework of the larynx (thyroid cartilage, both arytenoid cartilages, and cricoid cartilage), laryngeal structures (epiglottis, aryepiglottic folds, true and false vocal cords, and subglottic larynx), and proximal trachea at least 1 cm beyond the tumor (44,46). The anterior wall of the hypopharynx is also removed. To remove the cartilaginous framework of the larynx en bloc, the anterior attachments of the middle constrictor, thyropharyngeal, and cricopharyngeal muscles are severed. The anterior pharyngeal defect is closed with layers of overlapping soft tissue and muscle to form a cylindric tube called the neopharynx, which extends from the tongue base to the cervical esophagus. The trachea is brought anteriorly to form a stoma to complete the separation of the airway from the neopharynx.

Conservation laryngeal surgical techniques have been developed to maximize the balance between laryngeal function and effective tumor control. These procedures include vertical partial laryngectomy for glottic tumors, supraglottic laryngectomy for supraglottic tumors, supracricoid laryngectomy, and transoral laser microsurgery (36,43).

Contrast-enhanced Evaluation of the Postsurgical Patient

Teaching Point

The expected appearance of the neopharynx after total laryngectomy is that of a featureless tube extending from the oral cavity to the cervical esophagus (Fig 23). An abrupt kink may be pres-

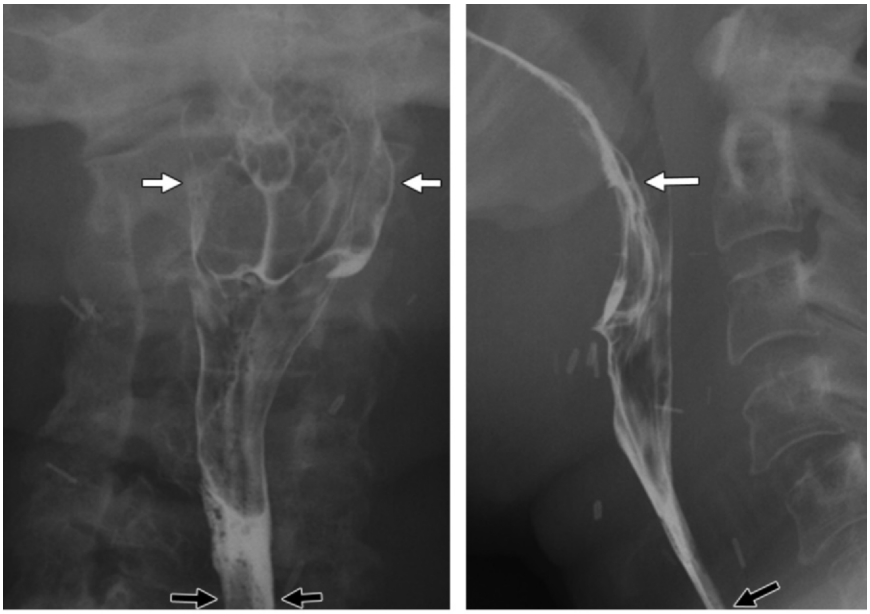


Figure 23. Expected postlaryngectomy appearance of the neopharynx. Anteroposterior **(a)** and lateral **(b)** images from an air-contrast barium pharyngogram show the neopharynx as a featureless inverted tube that extends from the tongue base (white arrows) to the upper esophageal sphincter (black arrows).

ent, marking the surgical closure site between the inferior aspect of the neopharynx and the cervical esophagus. In patients in whom unilateral radical neck dissection has been performed, the neopharynx may gently deviate toward the side of the dissection. Thickening of the prevertebral space anterior to C4 and C5 and indentation of the neopharynx are caused by posterior retraction of the thyropharyngeal and cricopharyngeal muscles due to loss of their normal anterior attachments. Differentiation of this expected postoperative appearance from a pathologic process requires fluoroscopic observation: Tumor nodules do not change shape during swallowing, whereas the cricopharyngeus typically undergoes contraction.

Early complications of total laryngectomy include sinus tract and pharyngocutaneous fistula formation due to tension on suture lines (44). Pharyngocutaneous fistula formation is more common in patients after radiation therapy or chemotherapy–radiation therapy. The most common site of fistula formation is near the tongue base at the top of the suture line (Fig 24); pull exerted by the tongue muscles tenses the suture line, which causes suture dehiscence. This same mechanism results in pseudodiverticulum formation at the anterior wall of the neopharynx in the midline near the tongue base. Large pseudodiverticula may trap food and impair swallowing. Early postoperative fistulas and sinus tracts are typically treated conservatively with wound packing, antibiotics, and cessation of oral intake. Pseudodiverticulum at the tongue base is treated with dietary modification or surgical removal (44).

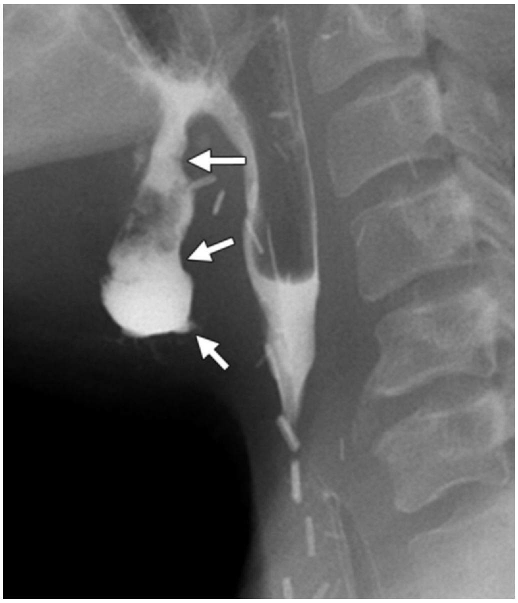


Figure 24. Postlaryngectomy leak in a 57-year-old woman who had undergone total laryngectomy for extensive supraglottic SCC. Lateral image from a water-soluble contrast material–enhanced pharyngogram shows leakage of contrast material from the base of the tongue into the postlaryngectomy bed (arrows).

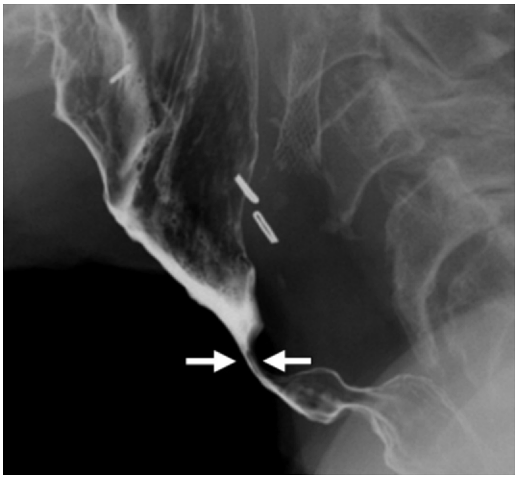


Figure 25. Short-segment stricture in an 83-year-old woman with a history of epiglottic SCC who had undergone total laryngectomy and postoperative radiation therapy. The patient complained of progressive dysphagia. Lateral image from an air-contrast barium pharyngogram shows smooth narrowing at the level of the cricopharyngeus (arrows).

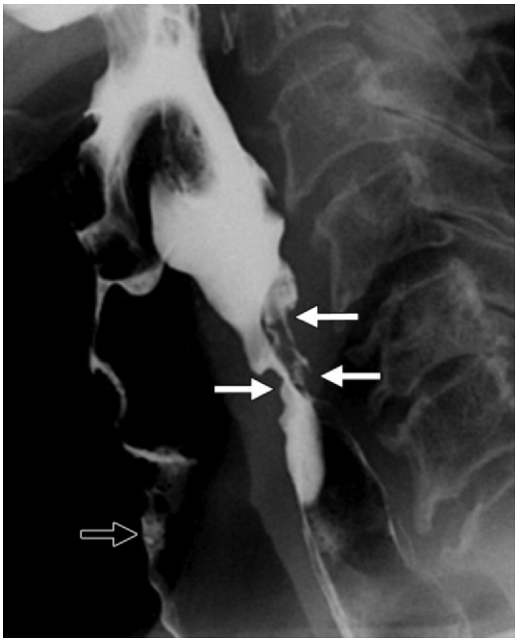


Figure 26. Postlaryngectomy recurrence in a 68-year-old woman with a history of supraglottic carcinoma who underwent supraglottic laryngectomy and adjuvant radiation therapy. The patient complained of persistent dysphagia and odynophagia. Lateral image from a barium pharyngographic study demonstrates nodular narrowing at the pharyngoesophageal junction (solid arrows), as well as aspiration of barium (open arrow). Endoscopy demonstrated recurrent SCC in the neopharynx that extended into the proximal cervical esophagus.

Benign pharyngoesophageal stricture or stenosis occurs as a result of ischemic or surgical mucosal injury or radiation effect (2). Benign strictures are smooth and retain a featureless mucosa (Fig 25). Short strictures are more commonly located at the inferior suture margin and usually respond to endoscopic dilation. Long-segment strictures involving much or all of the neopharynx are difficult to treat and may require multiple dilations or surgical reconstruction.

Recurrence after total laryngectomy occurs in approximately 31% of patients (when defined as locoregional recurrence, development of a second aerodigestive primary tumor, or distant metastasis) (44). The majority of patients have locoregional recurrence, predominantly in the neck or tracheostome. Pharyngographic depiction of a discrete mass, mucosal nodularity, or irregular narrowing (Fig 26) should prompt endoscopy and tissue sampling to evaluate for a pathologic process (2).

Conclusion

Familiarity with the normal pharyngeal anatomy and the appearances of multiple structural lesions affecting the pharynx should lead to improved understanding, recognition, and interpretation of findings at barium pharyngography.

References

1. Semenkovich JW, Balfe DM, Weyman PJ, Heiken JP, Lee JK. Barium pharyngography: comparison of single and double contrast. AJR Am J Roentgenol 1985;144(4):715–720.
2. Balfe DM, Heiken JP. Contrast evaluation of structural lesions of the pharynx. Curr Probl Diagn Radiol 1986;15(2):73–160.
3. Patterson J, Wilson JA. The clinical value of dysphagia preassessment in the management of head and neck cancer patients. Curr Opin Otolaryngol Head Neck Surg 2011;19(3):177–181.
4. Lin DT, Cohen SM, Coppit GL, Burkey BB. Squamous cell carcinoma of the oropharynx and hypopharynx. Otolaryngol Clin North Am 2005;38(1):59–74, viii.
5. Grant PD, Morgan DE, Scholz FJ, Canon CL. Pharyngeal dysphagia: what the radiologist needs to know. Curr Probl Diagn Radiol 2009;38(1):17–32.
6. Lindbichler F, Raith J, Uggowitzer M, Hausegger K. Aspiration resulting from lateral hypopharyngeal pouches. AJR Am J Roentgenol 1998;170(1):129–132.
7. Waldhausen JH. Branchial cleft and arch anomalies in children. Semin Pediatr Surg 2006;15(2):64–69.
8. Pezzettigotta SM, Leboulanger N, Roger G, Denoyelle F, Garabédian EN. Laryngeal cleft. Otolaryngol Clin North Am 2008;41(5):913–933, ix.
9. Leboulanger N, Garabédian EN. Laryngo-tracheo-oesophageal clefts. Orphanet J Rare Dis 2011;6:81.

10. El-Gohary Y, Gittes GK, Tovar JA. Congenital anomalies of the esophagus. Semin Pediatr Surg 2010;19(3):186–193.
11. Berrocal T, Madrid C, Novo S, Gutiérrez J, Arjonilla A, Gómez-León N. Congenital anomalies of the tracheobronchial tree, lung, and mediastinum: embryology, radiology, and pathology. RadioGraphics 2004;24(1):e17.
12. Waltzman ML. Management of esophageal coins. Curr Opin Pediatr 2006;18(5):571–574.
13. Young CA, Menias CO, Bhalla S, Prasad SR. CT features of esophageal emergencies. RadioGraphics 2008;28(6):1541–1553.
14. Smith D, Woolley S. Hypopharyngeal perforation following minor trauma: a case report and literature review. Emerg Med J 2006;23(1):e7.
15. Shah RK, Stocks C. Epiglottitis in the United States: national trends, variances, prognosis, and management. Laryngoscope 2010;120(6):1256–1262.
16. Guardiani E, Bliss M, Harley E. Supraglottitis in the era following widespread immunization against Haemophilus influenza type B: evolving principles in diagnosis and management. Laryngoscope 2010;120(11):2183–2188.
17. Barratt GE, Koopmann CF Jr, Coulthard SW. Retropharyngeal abscess: a ten-year experience. Laryngoscope 1984;94(4):455–463.
18. Brook I. Microbiology and management of peritonsillar, retropharyngeal, and parapharyngeal abscesses. J Oral Maxillofac Surg 2004;62(12):1545–1550.
19. Loehrl TA, Smith TL. Inflammatory and granulomatous lesions of the larynx and pharynx. Am J Med 2001;111(suppl 8A):113S–117S.
20. Miglets AW, Viall JH, Kataria YP. Sarcoidosis of the head and neck. Laryngoscope 1977;87(12):2038–2048.
21. Gilad R, Milillo P, Som PM. Severe diffuse systemic amyloidosis with involvement of the pharynx, larynx, and trachea: CT and MR findings. AJNR Am J Neuroradiol 2007;28(8):1557–1558.
22. Lam HC, Abdullah VJ, Soo G. Epiglottic cyst. Otolaryngol Head Neck Surg 2000;122(2):311.
23. DeSanto LW, Devine KD, Weiland LH. Cysts of the larynx: classification. Laryngoscope 1970;80(1):145–176.
24. Evans DA. Saccular cyst of the larynx. Otolaryngol Head Neck Surg 2003;128(2):303–304.
25. Thabet MH, Kotob H. Lateral saccular cysts of the larynx. Aetiology, diagnosis and management. J Laryngol Otol 2001;115(4):293–297.
26. Glazer HS, Mauro MA, Aronberg DJ, Lee JK, Johnston DE, Sagel SS. Computed tomography of laryngoceles. AJR Am J Roentgenol 1983;140(3):549–552.
27. Dursun G, Ozgursoy OB, Beton S, Batikhan H. Current diagnosis and treatment of laryngocele in adults. Otolaryngol Head Neck Surg 2007;136(2):211–215.
28. Siddiq MA, Sood S, Strachan D. Pharyngeal pouch (Zenker's diverticulum). Postgrad Med J 2001;77(910):506–511.
29. Ferreira LE, Simmons DT, Baron TH. Zenker's diverticula: pathophysiology, clinical presentation, and flexible endoscopic management. Dis Esophagus 2008;21(1):1–8.
30. Veenker E, Cohen JI. Current trends in management of Zenker diverticulum. Curr Opin Otolaryngol Head Neck Surg 2003;11(3):160–165.
31. Boisvert RD, Bethune DC, Acton D, Klassen DR. Bilateral Killian-Jamieson diverticula: a case report and literature review. Can J Gastroenterol 2010;24(3):173–174.
32. Ekberg O, Nylander G. Lateral diverticula from the pharyngo-esophageal junction area. Radiology 1983;146(1):117–122.
33. Rubesin SE, Levine MS. Killian-Jamieson diverticula: radiographic findings in 16 patients. AJR Am J Roentgenol 2001;177(1):85–89.
34. National Cancer Institute. PDQ laryngeal cancer treatment. Bethesda, MD: National Cancer Institute. http://www.cancer.gov/cancertopics/pdq/treatment/laryngeal/HealthProfessional. Updated February 23, 2012. Accessed March 2, 2012.
35. Cohan DM, Popat S, Kaplan SE, Rigual N, Loree T, Hicks WLJ Jr. Oropharyngeal cancer: current understanding and management. Curr Opin Otolaryngol Head Neck Surg 2009;17(2):88–94.
36. Chawla S, Carney AS. Organ preservation surgery for laryngeal cancer. Head Neck Oncol 2009;1:12.
37. Hristov B, Bajaj GK. Radiotherapeutic management of laryngeal carcinoma. Otolaryngol Clin North Am 2008;41(4):715–740, vi.
38. Blitz AM, Aygun N. Radiologic evaluation of larynx cancer. Otolaryngol Clin North Am 2008;41(4):697–713, vi.
39. Ward PH, Hanson DG. Reflux as an etiological factor of carcinoma of the laryngopharynx. Laryngoscope 1988;98(11):1195–1199.
40. Novacek G. Plummer-Vinson syndrome. Orphanet J Rare Dis 2006;1:36.
41. Pfister DG, Ang KK, Brizel DM, et al. Head and neck cancers. J Natl Compr Canc Netw 2011;9(6):596–650.
42. Priante AV, Castilho EC, Kowalski LP. Second primary tumors in patients with head and neck cancer. Curr Oncol Rep 2011;13(2):132–137.
43. Holsinger FC, Nussenbaum B, Nakayama M, et al. Current concepts and new horizons in conservation laryngeal surgery: an important part of multidisciplinary care. Head Neck 2010;32(5):656–665.
44. Agrawal N, Goldenberg D. Primary and salvage total laryngectomy. Otolaryngol Clin North Am 2008;41(4):771–780, vii.
45. Thawley SE, Sessions DG, Genden EM. Surgical therapy of hypopharyngeal tumors. In: Thawley SE, Panje WR, Batsakis JG, Linderg RD, eds. Comprehensive management of head and neck tumors. 2nd ed. Philadelphia, Pa: Saunders, 1999; 876–914.
46. Thawley SE. Surgical therapy of the larynx: surgical anatomy. In: Thawley SE, Panje WR, Batsakis JG, Linderg RD, eds. Comprehensive management of head and neck tumors. 2nd ed. Philadelphia, Pa: Saunders, 1999; 979–1005.

Easier to Swallow: Pictorial Review of Structural Findings of the Pharynx at Barium Pharyngography

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Page E190
The pharynx is anatomically divided into the oropharynx and hypopharynx by the pharyngoepiglottic fold, which is not typically seen at barium pharyngography. Therefore, either the base of the free margin of the epiglottis or the hyoid bone is used as a proxy landmark on static air-contrast images to delineate this boundary. The hypopharynx lies posterior and lateral to the laryngeal cartilages.

Page E193
Structural abnormalities of the pharynx are diagnosed by detecting a change in the normal coated surfaces or an alteration in density.

Page E198
A laryngocele is a saccular cyst that contains air and that maintains communication with the laryngeal lumen.

Page E200
Findings at barium pharyngography depend on tumor location and morphology. Large exophytic tumors prevent normal coating and displace coated mucosal surfaces. Infiltrating tumors tend to demonstrate ulceration.

Pages E205
The expected appearance of the neopharynx after total laryngectomy is that of a featureless tube extending from the oral cavity to the cervical esophagus.