# Chapter 98: Diagnostic Imaging of the Hypopharynx

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The hypopharynx is arbitrarily defined as that portion of the foregut extending from the hyoid bone to the cricopharyngeus muscle. It is in direct continuity with the oropharynx above and the proximal esophagus below. Radiographic examination can provide accurate anatomic information regarding the presence and extent of disease in the hypopharynx. In addition, it can provide important physiologic information regarding the swallowing mechanism in patients with dysphagia. Although the pharynx is usually readily accessible to direct and indirect visualization, inspection of one or more areas of the pharynx may be inadequate because of pain, trismus, a hyperactive gag reflex, or the presence of disease (Semenkovich et al, 1983). Radiographic examination of the hypopharynx is particularly useful in patients who are difficult to examine and in those whose endoscopic examination is inconclusive. This chapter details the radiographic anatomy of the hypopharynx and the appropriate use of the various imaging techniques available for examining this area.

## Techniques

### Soft tissue radiographs

Lateral and anteroposterior (AP) radiographs of the neck using soft tissue (low kilovoltage) technique are very useful, particularly for localizing radiopaque foreign boies and detecting increased thickness of the prevertebral soft tissues. Exposures should be mae while the patient phonates the vowel "e", since this places the tongue in an anterior position and permits better visualization of the air-filled pharynx (Seaman, 1983). Maximal distension of the hypopharynx can be obtained by having the patient blow through compressed lips (the modified Valsalva maneuver). When a foreign body is suspected, both lateral and AP views should be obtained, although the AP radiograph provides less diagnostic information because of superimposition of the cervical spine. Because of this superimposition, the AP radiographs should be more heavily exposed.

Thickening of the prevertebral soft tissue can occur with a retropharyngeal abscess (Figs. 98-1 and 98-2), a retropharyngeal hematoma, or a neoplasm (Fig. 98-3). It is important to expose the lateral radiograph during peak inspiration and with the neck extened to minimize the thickness of the prevertebral soft tissues (Seaman, 1983). During expiration the normal prevertebral soft tissues thicken and may simulate a prevertebral soft tissue mass. This is particularly true in infants and young children, whose prevertebral soft tissue thickness may increase more than threefold during expiration (Brenner, 1964).

Xeroradiography (Fig. 98-4) is advocated by some because of its edge enhancement characteristics, which provide clear delineation of the soft tissue planes of the neck (Smith and Ramsey, 1982). However, this method requires special equipment that is not available in all radiology departments.

## Tomography

Linear or complex motion tomography allows visualization of the pharynx without superimposition of the cervical spine. However, its usefulness is severely limited because of its inability to demonstrate lesions that are not profiled by the wall of the pharynx. Furthermore, tomography does not provide the anatomic detail demonstrated by contrast pharyngography, computed tomography (CT), or magnetic resonance imaging (MRI).

## Motion recording techniques

Motion recording techniques are essential for studying the functional dynamics of the pharynx because of the rapidity and complexity of highly coordinated events occurring during swallowing. Of the several types of motion recording currently available, *videorecording* is the most useful because it provides good spatial resolution, and the recorded images are immediately available for review. Although *cineradiography* provides excellent spatial resolution, it is no longer widely used because it requires costly, specialized equipment; the film must be developed before it can be reviewed; and the radiation exposure is significantly higher than with videorecording or camera techniques. *Rapid sequence spot film cameras* are capable of recording 1 to 12 images per second while exposing the patient to a significantly lower radiation dose. The images produced have adequate spatial resolution but do not provide the functional information displayed by continuous motion recording systems.

## Air contrast pharyngography

The air contrast technique provides the best mucosal detail of the hypopharynx and is particularly useful in patients with pharyngeal neoplasms. Following one or more swallows of a dense suspension of barium, frontal and lateral radiographs of the hypopharynx are obtained while the patient performs two simple maneuvers, phonation and the modified Valsalva maneuver (Fig. 98-5, Balfe and Heiken, 1986; Rubesin et al, 1987). During phonation (of the vowel "e"), the tongue moves forward, widening the AP diameter of the valleculae and the epiglottis (Fig. 98-5). With the modified Valsalva maneuver (blowing through compressed lips), the hypopharynx becomes distended with air and the piriform sinuses become dilated (Fig. 98-5, B). Oblique views may also provide additional information (Ekberg and Nylander, 1985; Taylor et al, 1991). Thus the barium-coated walls of the hypopharynx are delineated against the air contained within the hypopharynx. The hypopharynx is inspected by fluoroscopy immediately before the spot films are taken to ensure adequate mucosal coating of the palate, tongue, tonsils, valleculae, epiglottis, and piriform sinuses. It should be kept in mind that the air contrast technique provides little information about the proximal cervical esophagus since the cricopharyngeus muscle is closed when the patient performs the modified Valsalva maneuver. For this reason videotaped fluoroscopy or full-column views are necessary to evaluate the region of the pharyngoesophageal junction (Fig. 98-6).

Contrast laryngopharyngography, as originally described by Powers et al (1957), consists of the introduction of an oily radiopaque medium into the pharynx after the pharynx and larynx have been anesthetized with a topical agent. The contrast material is squirted over the back of the tongue during inspiration. The medium fills the valleculae and piriform sinuses and spills over into the larynx. Frontal and lateral radiographs are then obtained while the patient performs the two maneuvers described above in addition to the true Valsalva maneuver. Although this technique is a reliable method for demonstrating the extent of laryngeal neoplasms, it is rarely necessary now that CT and MRI have replaced contrast laryngography as the methods of choice for examining the larynx. Hypopharyngeal neoplasms are also well demonstrated by CT and MRI and by the simple techniques of double-contrast pharyngography.

### Full-column contrast pharyngography

Conventional spot film recording of the hypopharynx during the swallowing of a bolus of barium is occasionally helpful but has important limitations. Because of the rapid transit of barium through the pharynx during swallowing, precise timing is required to image the hypopharynx when it is maximally distended (Fig. 98. 6). When the hypopharynx is distended with barium, only the pharyngeal margins that are tangential to the x-ray beam can be seen; thus even large pharyngeal masses may be hidded by the dense column of barium.

### Water-soluble contrast examination

Iodinated water-soluble contrast media, such as meglumine and sodium diatrizoate, should be used when perforation of the pharynx or esophagus is suspected, since barium in the mediastinum may incite an inflammatory reaction (James et al, 1975). In addition, barium may be retained in an extrapharyngeal collection for a long period of time, making reexamination difficult. However, if an esophageal perforation is suspected but not shown by water-soluble contrast examination, immediate reexamination with barium sometimes demonstrates the abnormality (Dodds et al, 1982; Foley et al, 1982). On the other hand, patients who are known to aspirate or who are suspected of having a pharyngotracheal or esophagotracheal fistula should not be given water-soluble contrast media because these agents can cause chemical pneumonitis (Frech et al, 1970) or pulmonary edema (Chiu and Gambach, 1974; Reich, 1969).

Recently, nonionic and low osmolar water-soluble contrast agents have become available. In patients with suspected aspiration or tracheoesophageal fistula, these newer agents may be used since they may cause only minimal or temporary pulmonary sequelae. However, the utility of these agents in such circumstances has not been thoroughly tested.

### Computed tomography

CT is currently the method of choice for staging evaluation of neoplasms of the hypopharynx. Important contributions of CT include the ability to (1) delineate with great accuracy the relationship of a neoplasm to the vocal cords and other laryngeal structures, (2) demonstrate tumor extension into the deep tissue planes surrounding the larynx and hypopharynx, and (3) demonstrate regional lymph node involvement (Reede and Bergeron, 1986).

CT is fast and offers thin slice capability with excellent spatial resolution. Cortical bone is imaged well. Disadvantages of CT include the artifacts created by dental amalgam and thick body parts such as the shoulders.

Scans are performed with the patient lying supine and breathing normally (quiet respiration). The neck is hyperextended slightly, so that the central axis of the larynx and hypopharynx is perpendicular to the x-ray beam. The trans-axial slice plane is parallel to the laryngeal ventricle. Trans-axial images are then made at 5 mm intervals using 3 mm beam collimation. Various maneuvers such as phonation and a modified Valsalva maneuver are helpful in delineating hypopharyngeal pathologic conditions. Intravenous contrast material improves identification of vascular structures and differentiation of nodal metastases (Mancuso et al, 1981, 1983; Reede et al, 1982).

### Magnetic reconance imaging

MRI uses a high-strength magnetic field and pulsed radiofrequency waves to produce sectional images of the body. An advantage of MRI is its excellent soft tissue contrast, which results in superb edge definition of structures. Images can also be acquired in multiple planes without repositioning the patient. Unlike CT, no ionizing radiation or iodinated contrast agents are involved. Artifacts from dental amalgam and shoulders are also eliminated.

Unfortunately, MRI is slower than CT. Patients with hypopharyngeal masses are often elderly and have concomitant pulmonary disease that introduces motion artifact. The strong magnetic field precludes imaging patients with cardiac pacemakers and cerebral aneurysm clips.

MRI technique vary with scanner type and available hardware and software. Surface coils are essential to adequately image the neck (Jabour, 1990a; Lufkin and Hanafee, 1985). T1-weighted images superbly display anatomic relationships. Balanced and T2-weighted images further define the signal characteristics of the tissues. Imaging silce thickness is usually 3 to 5 mm. Gaps of 1 mm between slices improve individual slice quality. MRI is valuable in the assessment of tumors of the pharynx and larynx (Curtin, 1989; Dillon et al, 1983; Lufkin et al, 1983).

### Radiographic Anatomy

The radiographic anatomy of the hypopharynx is well demonstrated by the double-contrast technique (see Fig. 98-5). In the frontal view (see Fig. 98-5, A) the valleculae are seen as two relatively symmetric pouches superimposed over the superiorly directed arcuate shadow of the epiglottis. The valleculae may be slightly asymmetric and may appear somewhat irregular because of the presence of lymphoid tissue. Laterally and superiorly the valleculae are continuous with the lateral pharyngeal walls, which form the lateral borders of the oropharynx. The lateral borders of the hypopharynx are formed largely by the outer margins of the piriform sinuses, which appear as two inverted triangles located on either side of the larynx. It should be recognized that the piriform sinuces may be asymmetric in size, shape, and position (Carbajal et al, 1961). However, lack of distension of a piriform sinus should be regarded with suspicion since it is a sign of tumor infiltration. This is particularly true if this finding is observed at the apex of the piriform sinus, since tumors originating at this site are more typically infiltrative than exophytic. The apices of the triangular piriform sinuses are directed inferiorly and are connected medially by the postcricoid line. This arcuate line is formed by barium pooled at the margin of contact between the posterosuperior aspect of the larynx and the posterior wall of the hypopharynx. Disruption or irregularity of this line is abnormal and is usually indicative of an adjacent tumor or inflammatory process. The postcricoid line may disappear during the modified Valsalva maneuver because of separation of the posterior pharyngeal wall from the cricoid cartilage (Carbajal et al, 1961). The aryepiglottic folds can sometimes be seen as linear shadows extending in an oblique fashion inferiorly and laterally from the epiglottis to the arytenoids. On the frontal view the aryepiglottic folds should be symmetric. The portion of the hypopharynx inferior to the postcricoid line is normally collapsed, except during swallowing.

In the lateral projection (see Fig. 98-5, B and C), the valleculae are superimposed. Posterior to the valleculae the free portion of the epiglottis is seen in profile. The superimposed aryepiglottic folds appear as a slightly curved line slanting inferiorly and posteriorly from the free portion of the epiglottis to the arytenoid cartilages. The piriform sinuses, also superimposed, have a triangular shape in the lateral view and often contain a small amount of barium pooled in the inferiorly directed apices. During phonation the anterior walls of the piriform sinuses can be seen separated from the aryepiglottic folds. The posterior lamina of the cricoid cartilage often forms a slightly curved impression on the anterior surface of the hypopharynx, which in some patients may be quite prominent; this impression corresponds to the postcricoid line seen on the frontal view. Just inferior to this cricoid impression, a small indentation, which is variable in appearance, may be seen on full-column views (see Fig. 98-6, B). This indentation is caused by prolapse of lax mucosal folds over the ventral submucosal venous plexus (Pitman and Fraser, 1965). It may resemble a web but can be distinguished from a true web by its change in shape during swallowing. The piriform sinuses have no distinct posterior border and merge into the posterior pharyngeal wall, which is straight and parallel to the cervical spine. The cricopharyngeus muscle forms the inferior border of the hypopharynx and is seen on the lateral view as a smooth posterior indentation.

The normal anatomy of the hypopharynx is shown by CT and MRI is shown in Figs. 98-7 to 98-10.

## External Factors

The major adjacent structures that may affect the hypopharynx include the larynx, the thyroid and parathyroid glands, the cervical lymph nodes, and the cervical spine. In addition, the retropharyngeal space is an important location for disease processes that may involved the hypopharynx.

When a neck mass is present or suspected clinically, frontal and lateral soft tissue radiographs of the neck are helpful in localizing the mass with respect to the hypopharynx. Retropharyngeal masses cause localized or diffuse thickening of the prevertebral soft tissues and anterior displacement of the pharyngeal air shadow (see Figs. 98-1 to 98-3). In more pronounced cases, reverse curvature of the cervical spine may be observed (see Fig. 98-1). CT and MRI also evaluate the retropharyngeal space. Entities that primarily involve the lymph nodes are usually limited to the suprahyoid portion of the neck and spare the midline. As processes become extranodal, spread may eventually involve the midline and can track inferiorly to involve the mediastinum (Davis et al, 1990). Thickening of the retropharyngeal soft tissues can be caused by tumor, inflammation, retropharyngeal abscess, hematoma, or edema. The most common retropharyngeal tumor in childhood is cystic hygroma (Barnhart and Brown, 1967). Other tumors occurring in childhood in the retropharyngeal region include ectopic goiter (Capitanio and Kirkpatrick, 1968), teratoma (Kogutt and Cohen, 1977), neurofibroma (Steichen et al, 1971), hemangioma, and primary or secondary neuroblastomas. In adults the most common tumors to thicken the prevertebral soft tissues are primary neoplasms of the pharynx and larynx (see Fig. 98-3). Retropharyngeal abscesses may be primary or may occur secondary to pharyngeal perforation by a foreign body or attempts at intubation. Retropharyngeal hematomas are uncommon but may be caused by trauma to the pharynx or cervical spine.

Although the radiographic findings in these conditions are nonspecific, one may occasionally see the calcification in a teratoma or neuroblastoma, air bubbles in a retropharyngeal abscess (see Fig. 98-1), or bone destruction and calcified lymph nodes in association with a tuberculous retropharyngeal abscess (see Fig. 98-2). However, in general one cannot differentiate one lesion from another on the basis of the plain radiographs alone. If a retropharyngeal goiter is suspected, radioisotope examination can identify the abnormal thyroid tissue. Ultrasound and CT can be used to distinguish between cystic and solid neck masses.

Edema of the retropharyngeal soft tissues can occur secondary to trauma (Swischuk, 1980) and produces diffuse thickening of the prevertebral soft tissues. Myxedematous thickening of the prevertebral soft tissues has also been described as a manifestation of hypothyroidism in neonates (Grunebaum and Moskowitz, 1970). Tumors or asbcesses arising in the submandibular regon may cause posterior displacement of the hypopharyngeal air shadow. Goiter (Fig. 98-11) or massive cervical lymph node enlargement from lymphoma or other head and neck tumors may cause lateral or posterior deviation of the hypopharynx. Large osteophytes projecting from the anterior margin of the cervical spine may indent the posterior aspect of the hypopharynx and are a potential cause of dysphagia (Bulos, 1974).

## Foreign Bodies

Examination of patients suspected of having a foreign body lodges in the hypopharynx should begin with lateral and frontal soft tissue radiographs of the neck. Of great importance is the differentiation of discrete areas of ossification within the laryngeal cartilages from bony foreign bodies, since bones are the largest group of foreign bodies found in the air and food passages (Muroff and Seaman, 1974). Most small spicules of bone lodge in the lower pole of a tonsil, at the base of the tongue, or in a vallecula (Jackson, 1948). Larger bones and other foreign bodies usually lodge in the region of the cricopharyngeus muscle (Fig. 98-12; Jackson, 1948). Cricoid cartilage ossification, because of its shape and position, causes the most difficulty in differentiation from a bony foreign body (Muroff and Seaman, 1974). Curvilinear ossification in the superior tip of the cricoid lamina and vertical ossification of the posterior margin of the cricoid lamina may both resemble bony foreign bodies (Hately egt al, 1965). Confusion may also arise when isolated areas in the posterior lamina and inferior horn of the thyroid cartilage are ossified.

It is important to remember that most foreign bodies lodge below the level of the cricoid cartilage. Therefore radiographs should include the lower cervical spine and the region of the thoracic inlet (Muroff and Seaman, 1974). Because these areas may be difficult to evaluate radiographically, Epstein (1955) has suggested taking the radiographs while the patient executes a suspended swallow, a maneuver that elevates the larynx about the height of one vertebral body.

A nonopaque foreign body such as meat can often be suspected on the basis of air trapped within it. A barium swallow examination may be helpful in identifying a non-opaque foreign body as a filling defect within the hypopharynx or esophagus (Fig. 98-13). When conventional radiographic methods are nondiagnostic, CT may identify a hypopharyngeal or esophageal foreign body (Gamba et al, 1983).

## Motility Disorders

### Normal deglutition

The act of swallowing involves the precise coordination of a number of complex and rapidly occurring neuromuscular events. Three major functions occur in the pharynx during the process of deglutition: (1) the propulsion of food into the esophagus, (2) the closure of entrances into the nasopharynx and larynx, and (3) opening of the cricopharyngeal sphincter (Seaman, 1978). Malfunction of any of these processes may result in dysphagia.

The following is a description of the normal sequence of motor event occurring during swallowing as observed by motion recording techniques (Atkinson et al, 1957; Bosma, 1957; Donner, 1974; Donner and Siegel, 1965). Entrance of food into the mouth is accommodated by depression of the tongue and elevation of the soft palate. The tongue collects the food by forming a central throughlike depression. Swallowing is initiated by transport of the food bolus from the oral cavity to the pharynx. This is accomplished by approximation of the tongue and soft palate, followed by elevation and posterior movement of the tongue against the hard palate. Approximation of the palate against the posterior pharyngeal wall prevents nasopharyngeal regurgitation. The overal motion during deglutition consists of a primary elevation of the entire pharynx followed by a descending peristaltic wave. Because obliteration of the pharyngeal cavity is achieved primarily by the posterior thrust of the tongue, the posterior pharyngeal wall normally exhibits little motion. As the food bolus proceeds into the hypopharynx, the epiglottis tilts posteriorly to deflect the bolus into the lateral food channels and then bends inferiorly to cover the laryngeal vestibule. As the food bolus passes through the hypopharynx, the cricopharyngeus muscle relaxes to allow transport of the bolus into the esophagus.

### Abnormal deglutition

Radiographic manifestations of altered pharyngeal function may be categorized as follows: (1) incomplete emptying of the pharynx or stasis, (2) abnormal pharyngeal motility, (3) misdirection of the swallowe bolus, and (4) cricopharyngeal dysfunction (Seaman, 1976).

Incomplete emptying of the pharynx can be caused by neuromuscular dysfunction, decreased muscular tone, altered sensitivity of the pharyngealmucosa, or mechanical obstruction at the level of the cricopharyngeus or cervical esophagus. Stasis occurs with pathologic outpouching of the pharynx and, in the absence of distal obstruction, is a reliable sign of pharyngeal motor dysfunction. Residual barium in the hypopharynx may lead to aspiration pneumonia since the resumption of breathing after completion of a swallow sucks any residual material from the pharynx into the tracheobronchial tree (Seaman, 1976).

Retention of barium in the valleculae should not be construed as a sign of disease, since it occurs in normal individuals.

Abnormal pharyngeal motility can be caused by disorders involving the brainstem, the myoneural junction (myasthenia gravis), or the pharyngeal musculature. With unilateral pharyngeal palsy, swallowed barium is thrown to the atonic side of the pharynx by the functioning pharyngeal constrictor muscle. This results in asymmetry of the barium-filled hypopharynx, which may be misinterpreted as neoplastic involvement of the normally contracting side of the pharynx (Kirchner, 1958; Seaman, 1983). Such a diagnostic error can be avoided by carefully observing the motion of the pharynx during several swallows of barium.

Myasthenia gravis can produce a number of abnormalities of deglutition, including hesitancy in initiating a swallow and slow, inefficient tongue movements that become progressively weaker with continued attempts at swallowing (Seaman, 1983). Pooling and stasis of barium in the pharynx are associated with loss of tone and ballooning of the pharyngeal cavity. Inability to approximate the base of the tongue to the palate and posterior pharyngeal wall effectively may result in nasopharyngeal regurgitation. Laryngeal aspiration may also occur. The pathognomonic feature of myasthenia gravis is the marked improvement following the administration of neostigmine.

Disease processes that directly affect the pharyngeal musculature, such as dermatomyositis, systemic lupus erythematosus, myotonic dystrophy, and oculopharyngeal myopaty, can produce abnormal deglutition. The radiographic findings may include prolonged muscular activity, weakened pharyngeal contractions, and pharyngeal retention and stasis.

## Cricopharyngeal dysfunction

The cricopharyngeus muscle relaxes just before the arrival of a peristaltic wave to allow the food bolus to pass into the esophagus. Thus the normally functioning cricopharyngeus muscle produces no indentation on the barium column as the bolus passes through the pharyngoesophageal junction (see Fig. 98-6, B). However, when the normally high resting tone of the cricopharyngeus is incompletely relaxed during deglutition, a smooth rounded impression is seen indenting the posterior aspect of the barium column at the level of the fifth or sixth vertebral body (Fig. 98-14). The vertical dimension of this protrusion is never more than 1 cm (Seaman, 1969). Complete or incomplete failure of relaxation of the cricopharyngeus muscle is termed *cricopharyngeal achalasia* and is a common cause of dysphagia. This type of cricopharyngeal dysfunction may result from a large number of disorders, including cerebrovascular occlusive disease, pseudobulbar palsy, nasopharyngeal cancer, poliomyelitis, thyroid myopathy, cervical vagotomy, surgical ablation of the pharynx, schizophrenia, polymyositis, dermatomyositis, oculopharyngeal syndrome, amyotrophic lateral sclerosis, and hiatus hernia (Seaman, 1966). Many cases are idiopathic. The most common cause is cerebrovascular disease (Seaman, 1983). Minor degrees of incomplete cricopharyngeal relaxation are observed in approximately 5% of asymptomatic individuals over 40 years of age and are of no clinical significance (Seaman, 1976).

Delayed opening of the cricopharyngeus, resulting in aspiration and repeated pulmonary infections, occurs in familial dysautonomia (Margulies et al, 1968). This disorder differs from cricopharyngeal achalasia in that once the cricopharyngeus does open, it opens completely.

The term *cricopharyngeal chalasia* is used to denote the circumstances in which the normal zone of high resting pressure at the pharyngoesophageal junction is absent or reduced; thus the cricopharyngeal sphincter is incompetent. This abnormality is a specific one, occurring only in patients with myotonic dystrophy (Pierce et al, 1965; Siegel et al, 1966). The radiographic manifestations of this disorder is the presence of a continuous column of barium extending from the pharynx into the cervical esophagus even when the patient is now swallowing (Pierce et al, 1965; Seaman, 1969; Siegel et al, 1966).

Premature closure of the cricopharyngeus muscle resulting in high intrapharyngeal pressure appears to play an important role in the pathogenesis of Zenker's diverticula (Ardran et al, 1964; Ellis et al, 1969). These posterior pharyngeal diverticula are discussed below.

## Diverticula

Pharyngeal diverticula may be congenital or acquired and are usually classified as either lateral or posterior. Although anterior pharyngeal pouches have been reported, they probably represent nothing more than overly developed vallecular fossae (Atkinson, 1945). The anterior pharyngeal recess seen occasionally following totoal laryngectomy will be discussed in the section dealing with the postoperative pharynx. Most pharyngeal diverticula are of the pulsion type. Traction diverticula caused by inflammatory changes, trauma, or neoplasm are rare (Zaino and Beneventano, 1977).

### Lateral diverticula

Hemispheric bulges of the lateral pharyngeal wall are observed frequently when the pharynx is fully distended with barium or air (Fig. 98-15). These protrusions occur in the anterolateral portion of the piriform sinuses at the level of the valleculae and are usually bilateral. Such pouches, aslo referred to as hypopharyngeal ears or pharyngoceles, represent lateral bulges in the intact thyrohyoid membrane and are of no clinical significance.

True lateral pharyngeal diverticula are rare. The acquired type occurs when hypopharyngeal mucosa protrudes through a defect in the thyrohyoid membrane (Fig. 98-16, Bachman et al, 1968; Wilson, 1962). It may be difficult to differentiate this type of pulsion diverticula from an unusually large pharyngeal pouch. Congenital lateral pharyngeal diverticula arise from vestiges of the third and fourth branchial clefts, which connect with the pharynx internally and end blindly in the neck (Bachman et al, 1968). They are usually located in the tonsillar fossa and have long, narrow necks (Wilson, 1962). Narrow-necked pharyngeal diverticula, whether congenital or acquired, may cause dysphagia by retaining ingested material.

Ekberg and Nylander (1983a) have described another type of lateral diverticulum occurring just below the transverse portion of the cricopharyngeus muscle at the pharyngoesophageal junction (Fig. 98-17). This diverticulum may have a wide or narrow opening; its clinical significance is yet to be determined.

## Posterior diverticula

The most common type of hypopharyngeal diverticulum is Zenker's diverticulum, which occurs posteriorly at the separation between the transverse and oblique fibers of the cricopharyngeus muscle. This spot is an anatomic weak point known as Killian's dehiscence. Zenker's diverticula appear to be the result of increased intrapharyngeal pressure caused by premature closure of the cricopharyngeus muscle during swallowing (Ardran et al, 1964; Ellis et al, 1969).

The radiographic appearance of Zenker's diverticulum varies with its size. A small diverticulum appears as an outpouching along the posterior hypopharyngeal wall just above the cricopharyngeal muscle impression. When a large diverticulum is present, an air fluid level may be observed on upright radiographs of the neck or upper chest (Fig. 98-18, A). This finding results from retention of secretions, food, and swallowed air in the pouch. On barium swallow examination a large sac is seen projecting posteriorly and inferolaterally, usually to the left (Fig. 98-18; B). On occasion, a large diverticulum may contain enough swallowed material to compress the cervical esophagus and cause dysphagia.

## Webs

The radiographic detection of webs in the hypopharynx and cervical esophagus is highly dependent on the technique used. Routine radiographic examination of the hypopharynx using spot films rarely demonstrates webs. However, then dynamic recording techniques are employed, hypopharyngeal and cervical esophageal webs can be demonstrated in 5.5% to 8% of patients undergoing barium swallow examination (Clements et al, 1974; Nosher et al, 1975). Clements et al (1974) have reported a 16% incidence of webs in 50 nonselected autopsies. The relationship of webs to dysphagia and other diseases is still controversial, although Nosher et al (1975) have provided convincing evidence that most hypopharyngeal and cervical esophageal webs are of no clinical significance.

Most webs are located within 2 cm of the pharyngoesophageal junction (Nosher et al, 1975). The typical web appears radiographically as a perpendicular linear filling defect arising from the anterior wall of the cervical esophagus or hypopharynx (Fig. 98-19). Its thickness is uniform and rarely exceeds 2 mm. Because of their anterior location, webs are best seen in the lateral projection, although a small indentation may be observed on the frontal view as a result of lateral extension. Rarely, webs are circumferential (Fig. 98-20). The portion of the esophagus immediately distal to a web may not fill immediately because of interruption of the flow of barium (Miller and Lewis, 1963). Webs only rarely occlude enough of the lumen to cause dysphagia (Seaman, 1983). When dysphagia is caused by an extensive web, the web may not be recognizable as such but is brought to attention by the jet of contrast that squirts through the narrow hypopharyngeal opening (Seaman, 1967; Shauffer et al, 1977). The postcricoid venous plexus impression may closely resemble a web but can be distinguished by its change in shape during swallowing (Pitman and Fraser, 1965). The impression caused by the incompletely relaxed cricopharyngeus muscles is easy to differentiate from a web because it always arises posteriorly and is greater than 2 mm in thickness.

Although webs may be a complication of certain skin diseases such as epidermolysis bullosa (Kabakian and Dahmash, 1978; Orlando et al, 1974) and benign mucous membrane pemphigoid (Agha and Raji, 1982; Al-Kutoubi and Eliot, 1984), most hypopharyngeal and cervical esophageal webs are incidental findings (Nosher et al, 1975). The relationship of webs to the so-called Plummer-Vinson syndrome remains controversial (Seaman, 1983). The etiology of hypopharyngeal and cervical esophageal webs is unknown.

**Neoplasms**

The vast majority of neoplasms arising in the hypopharynx are epidermoid (squamous cell) carcinomas. Occasionally the radiologist is the first to make the diagnosis of carcinoma of the hypopharynx when a patient with vagus symptoms is referred for a barium swallow examination. However, the primary role of imaging in the evaluation of hypopharyngeal tumors is not diagnosis but determination of the precise location and extent of disease. In this regard, CT, MRI, and double-contrast pharyngography are extremely useful. Compared to clinical evaluation, CT can add valuable information about submucosal spread of tumor, invasion of cartilage, and involvement of lymph nodes (Asperstrand et al, 1990; Reid, 1984). CT and MRI are very valuable for determining extent of disease by demonstrating tumor invasion into the larynx and paralaryngeal spaces. CT is superior to contrast laryngopharyngography in determining precise tumor extent (Archer et al, 1981; Mancuso and Hanafee, 1979) and is capable of demonstrating involvement of the cervical lymph nodes (Mancuso et al, 1981, 1983; Reede et al, 1982). Although double-contrast pharyngography is generally inferior to CT in determining precise location and extent of disease, it may demonstrate mucosal involvement in areas that are difficult to evaluate endoscopically (Balfe and Heiken, 1986). Moreover, careful evaluation of the entire pharynx and esophagus is important in all patients with head and neck tumors because of the high incidence of second primary cancers involving the upper digestive tract (Bundrick and Cho, 1983; Gluckman et al, 1980; McGuirt, 1982). Full-column pharyngography is of limited utility in evaluating hypopharyngeal tumors because when the hypopharynx is distended with barium, only the pharyngeal margins that are tangential to the x-ray beam can be seen; thus even large pharyngeal masses may be hidden by the dense barium column. Videorecording during the swallowing of barium is often useful for examining the postcricoid area, which is difficult to visualize on air contrast pharyngography. As a relatively recent imaging technique, MRI is proving to be extremely useful for evaluating the neck. On T1-weighted images, fat has a high signal intensity and provides excellent soft tissue contrast with lymph nodes and infiltrating tumor. T2-weighted images provide contrast between cancers and the mucosal and muscular tissues (Dillon, 1986).

The discussion in this section will include neoplasms involving the piriform sinuses, postcricoid region, posterior hypopharyngeal wall, and epilarynx. The epilarynx is the portion of the supraglottic region that includes the posterior surface of the epiglottis and the aryepiglottic folds. Epilaryngeal cancers are considered by some investigators to be hypopharyngeal tumors because of their similar natural history and morphology (Fletcher and Hamberger, 1974; Lederman, 1970).

## Piriform sinuses

Piriform sinuses tumors spread by direct invasion of adjacent structures and by lymphatic dissemination to regional nodes (Kirchner, 1977; Larsson et al, 1981). Tumors involving the medial wall of the piriform sinus tend to invade the medial wall of the piriform sinus tend to invade the laryngeal vestibule and arytenoid and cricoid cartilage, whereas those of the lateral wall tend to infiltrate the thyroid cartilage and the lateral hypopharyngeal wall (Carbajal et al, 1961). Findings on double-contrast pharyngography include filling defects, rigidity of the piriform sinus walls, mucosal irregularity, and elevation of the postcricoid line (Fig. 98-21; Carbajal et al, 1961). A serious limitations of contrast pharyngography is that when a piriform sinus tumor involves the posterior cricoid region, only the superior portion of the lesion is well seen (Carbajal et al, 1961). On CT or MRI, a mass is seen posterolaterally within the framework of the laryngeal skeleton (Fig. 98-22). Any soft tissue between air in the piriform sinus and the inner margin of the thyroid cartilage indicates tumor (Gamsu, 1983). Frequently the tumor has grown through the thyrohyoid membrane or thyroid cartilage to invade the soft tissues of the neck (Fig. 98-23; Kirchner, 1977; Olofsson and Van Nostrand, 1973; Tucker, 1974). Another important area of extention is through the conus elasticus into the cricothyroid this region precludes partial laryngectomy (Ogura and Heeneman, 1973). Inferior tumor spread is to the paralaryngeal tissues lateral to the true and false cords. This area is best evaluated during quiet breathing. Piriform sinus tumors may also grow superiorly and anteriorly to infiltrate the aryepiglottic folds and preepiglottic space (Fig. 98-22). The aryepiglottic folds should be assessed during phonation because during quiet breathing the piriform sinuses are usually collapsed. Increased thickness of an aryepiglottic fold indicates tumor involvement. Increased tissue density in the preepiglottic space may represent either tumor infiltration or edema (Gamsu, 1983).

## Epilaryngeal region

Epilaryngeal tumors frequently invade surrounding structures and metastasizes to regional lymph nodes. Depending on the site of origin, epilaryngeal tumors may spread to the valleculae, base of tongue, pharyngeal walls, infrahyoid epiglottis, preepiglottic space, and aryepiglottic folds.

On double-contrast pharyngography these tumors may appear as exophytic masses or may cause distortion or destruction of the normal hypopharyngeal structures (Fig. 98-24). Normally, the aryepiglottic folds are not well seen in the frontal projection. However, when enlarged from tumor involvement or edema, the aryepiglottic folds are clearly demonstrated (Carbajal et al, 1961). Asymmetry of the aryepiglottic folds in the frontal or lateral view is another sign of tumor involvement.

CT and MRI are capable of demonstrating tumor invasion into the preepiglottic space (Fig. 98-25) and can document contralateral spread (Archer et al, 1981; Gamsu et al, 1981; Jabour et al, 1990b; Larsson et al, 1981). Extension of tumor superiorly into the valleculae may be difficult to detect with CT unless it is extensive, but tumor in this area is easily assessed endoscopically. Imaging can demonstrate infiltration of the glossoepiglottic and lateral pharyngoepiglottic folds. Tumor involvement of the aryepiglottic folds should be assessed during phonation since during quiet respiration the piriform sinuses are usually collapsed. Tumor involvement is recognized as thickening of the aryepiglottic fold. Lateral extension of epilaryngeal tumor into the paralaryngeal soft tissues may be seen as posterior displacement of the piriform sinus. Distortion of the piriform sinus can be best evaluated when the sinus is distended during phonation (Gamsu et al, 1981).

### Posterior hypopharyngeal wall

Tumors involving the posterior hypopharyngeal wall cause thickening of the retropharyngeal soft tissues by direct extension or by spread to the lateral and retropharyngeal lymph nodes (see Fig. 98-3; Davis et al, 1990; Mancuso and Hanafee, 1985). These tumors tend to cross the midline and may extend inferiorly to the level of the cricopharyngeus.

### Postcricoid region

The postcricoid region of the hypopharynx and the area of the pharyngoesophageal junction are normally collapsed, except during swallowing. Therefore these areas are best evaluated by full-column pharyngoesophagography or videotaped fluoroscopy while the patient swallows a thin suspension of barium. Tumors involving these areas may appear as strictures or contour irregularities and can be very difficult to demonstrate.

### Lymph node metastases

Tumors of the hypopharynx tend to be less differentiated and more aggressive than endolaryngeal tumors and thus have a high incidence of lymph node metastases (Kirchner, 1977; Olofsson and Van Nostrand, 1973; Tucker, 1974). CT and MRI are capable of detecting clinically occult nodal involvement (Fig. 98-26; Dooms et al, 1984; Mancuso et al, 1981; Reede and Bergeron, 1986; Stark et al, 1984). On CT, lymph nodes are similar in density to muscle and usually are embedded in low-density fat. Intravenously administered contrast is helpful in differentiating nodes from blood vessels. Lymph nodes are isointense or slightly hyperintense to muscle and hypointense to fat on T1-weighted MRI (Fig. 98-27). On T2-weighted images, nodes are hyperintense to muscle and isointense to fat (Jabour et al, 1990a). Necrotic portions of pathologic nodes usually have decreased signal on T1-weighted images and increased signal on T2-weighted images (Fig. 98-28). An advantage of MRI is that intravenous contrast material is unnecessary in differentiating lymph nodes from vessels.

The following imaging findings are indicative of nodal disease (Mancuso and Hanafee, 1985; Reede and Som, 1991; van der Brekel et al, 1990) but can be produced by benign conditions as well as malignancies: (1) a nonenhancing mass larger than 1.5 cm in diameter in the submandibular or jugulodigastric lymph node-bearing areas or larger than 1.0 cm in diameter in other lymph node-bearing areas; (2) a mass of any size with a central nonfat lucent CT attenuation in a lymph node-bearing areas; (3) obliteration of fascial planes around enlarged nodes in a nonoperated or nonirradiated neck; and (4) three or more contiguous, ill-defined nodes measuring 8 to 15 mm in diameter or greater. Although not an absolute criterion, metastatic lymph nodes tend to be spheric in shape rather than ovoid (Som, 1987). When enlarged lymph nodes can be palpated clinically, imaging can be useful in identifying the relationship of the metastatic lymphadenopathy to the carotid artery and jugular vein. Nodal fixation has been eliminated from the clinical staging system; however, fixation is implied when a nodal mass completely surrounds a structure such as a blood vessel. Ultrasound is helpful in establishing vascular invasion by demonstrating poor definition of the vessel wall (Hajek et al, 1986). Of note is that neither CT nor MRI may distinguish consistently between enlarged matted lymph nodes and direct extension of tumor into the soft tissue of the neck. MRI is superior to CT, however, in showing the relationship of tumor mass to muscle (Glazer et al, 1986). Because the imaging findings are not specific for metastatic disease, the scan must be correlated with the patient's history and other clinical data.

## Posttreatment Appearance of Hypopharynx

### Radiation therapy

Dysphagia is a common problem in patients who have received radiation therapy for pharyngeal cancer. Such patients should be evaluated with both air contrast and dynamic recording techniques to assess pharyngeal anatomy and motility. The most commonly observed motility disturbance in this group of patients is failure of the epiglottis to tilt completely down over the laryngeal inlet during swallowing (Ekberg and Nylander, 1983b). As a result, aspiration occurs and may be compounded by paresis of the pharyngeal constrictor muscles, another sequela of irradiation. An additional functional abnormality that may be observed in these patients is delayed relaxation of the cricopharyngeus muscle.

After radiation treatment, patients examined by pharyngography commonly exhibit diffuse, smooth symmetric swelling of the mucosa included within the radiation port. Recurrent or persistent mucosal tumor, by contrast, characteristically produces irregularity or ulceration in addition to asymmetric thickening (Balfe and Heiken, 1986).

### Total laryngectomy

Dysphagia has been reported to occur in 16% of patients after total laryngectomy (Jung and Adams, 1980) and may result from pharyngeal or cricopharyngeal dysmotility (Schobinger, 1957), recurrent tumor, or benign stricture (Balfe et al, 1982). Because physical examination is difficult in total laryngectomy patients and because the accuracy of esophagoscopy and biopsy in detecting recurrent tumor is limited (Jung and Adams, 1980), barium examination of the pharynx and esophagus can provide important information.

Radiographically the normal neopharynx has the appearance of a relatively straight, featureless tube to the level of the cricopharyngeal impression (Fig. 98-29; Balfe et al, 1982). Recurrent tumor may present as mucosal irregularity or ulceration, a focal spheric mass that abruptly deviates the neopharynx from its straight course, or narrowing of the lumen of the neopharynx (Fig. 98-30). However, recurrences that are not directly adjacent to the neopharynx produce no detectable abnormality on barium pharyngography. For this reason, nonmucosal recurrence is best evaluated by CT (Figs. 98-31 and 98-32; DiSantis et al, 1984a). CT is capable of demonstrating soft tissue masses arising near the tracheostomy site, deep to the sternocleidomastoid muscles, or in cervical lymph node chains posterior and lateral to the neopharynx (Fig. 98-32).

Barium pharyngography is also useful in detecting benign complications of total laryngectomy such as postoperative fistulas and benign strictures (Balfe et al, 1982). Benign strictures tend to be of two types. Short-segment areas of narrowing occur at the distal surgical closure and are probably local deformities resulting from surgery. Long-segment, tapered narrowings usually occur in the midportion of the neopharynx and may be the result of radiation therapy.

Another benign abnormality that may be observed after total laryngectomy is an anterior pouch near the base of the tongue that results from separation of the edges of the pharyngeal closure at the point where it joins the tongue base (Fig. 98-33). Regurgitation from such a pouch may cause dysphagia (Kirchner et al, 1963).

Occasionally, the posterior pharyngeal wall may appear thickened and may simulate a mass. This appearance is caused by bunching together of the inferior constrictor and cricopharyngeus muscles that have been deprived of their normal anterior attachment (Fig. 98-33; Kirchner et al, 1963).

## Conservation laryngectomy surgery

Vertical hemilaryngectomy is a procedure used to treat localized carcinoma of the true vocal cord. Dysphagia and suspected aspiration are the two most common reasons for radiologic evaluation after this type of surgery. Because the surgical procedure is confined to the larynx, barium examination shows a normal pharynx and hypopharynx (DiSantis et al, 1983). Recurrent tumor can be detected when barium is aspirated into the larynx and trachea. Radiographic manifestations of local recurrence include mucosal irregularity of the hemilarynx and mass effect deforming the airway (Fig. 98-34; DiSantis et al, 1983). In patients in whom there is either radiographic demonstration or clinical suspicion of recurrent disease, CT is a useful supplement to the physical examination and indirect laryngoscopy. On CT, increased width of the residual true vocal cord and convexity of the pseudocord at the level of the glottis are the most realiable signs of recurrent tumor (Fig. 98-35; DiSantis et al, 1984b). CT can also demonstrate cervical lymph node involvement.

Subtotal supraglottic laryngectomy and partial laryngopharyngectomy are performed less commonly for localized pharyngeal tumors. Contrast pharyngograms performed on patients who have undergone these procedures commonly show entrance of contrast into the residual laryngeal vestibule and trachea, thus allowing evaluation of the endolaryngeal structures as well as the pharynx. CT is an important method for evaluating suspected recurrences in this group of patients as well and is superior to pharyngography in demonstrating nonmucosal soft tissue extent of the disease (Niemeyer et al, 1987).