RadioGraphics

# From the Radiologic Pathology Archives[1]

## Esophageal Neoplasms: Radiologic-Pathologic Correlation[2]

*Rachel B. Lewis, MD • Anupamjit K. Mehrotra, MD • Pablo Rodriguez, MD • Marc S. Levine, MD*

**SA-CME**

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**LEARNING OBJECTIVES FOR TEST 6**

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

- Describe the clinical and pathologic features of esophageal neoplasms.
- List the imaging characteristics of esophageal neoplasms.
- Discuss the differential diagnosis for esophageal neoplasms.

**TEACHING POINTS**

*See last page*

Esophageal neoplasms have a wide spectrum of clinical features, pathologic findings, and imaging manifestations. Leiomyomas are the most common benign esophageal neoplasm, typically appearing as smoothly marginated intramural masses. Fibrovascular polyps arise in the cervical esophagus, gradually elongating as they are pulled inferiorly by esophageal peristalsis. Granular cell tumors are generally incidental small intramural masses with an appearance similar to that of leiomyomas. Malignant esophageal neoplasms are a common cause of cancer mortality, particularly squamous cell carcinoma (SCC) and adenocarcinoma. Both of these tumors occur in older men, most often appearing as irregular infiltrative lesions at barium examination, with evidence of tumor spread beyond the esophagus at cross-sectional imaging. Adenocarcinoma arises from Barrett esophagus and is much more likely than SCC to involve the gastroesophageal junction. Esophageal involvement by lymphoma is usually secondary to tumor spread from the stomach or mediastinum. Spindle cell carcinoma is a biphasic malignancy with carcinomatous and sarcomatous elements that forms a bulky polypoid intraluminal mass. Neuroendocrine carcinoma is an aggressive neoplasm that may be hypervascular and is usually associated with metastatic disease at presentation. Understanding the imaging appearances and pathologic bases of esophageal neoplasms is essential for their detection, differential diagnosis, staging, and treatment planning.

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**Abbreviations:** FDG = fluorine 18 fluorodeoxyglucose, GIST = gastrointestinal stromal tumor, H-E = hematoxylin-eosin, HIV = human immunodeficiency virus, SCC = squamous cell carcinoma,

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[1]Supported by the American Institute for Radiologic Pathology (AIRP), the Joint Pathology Center (JPC), and Uniformed Services University of the Health Sciences (USU).

[2]From the American Institute for Radiologic Pathology, 1010 Wayne Ave, Suite 320, Silver Spring, MD 20910 (R.B.L.); Department of Radiology, University of Chicago Medical Center, Chicago, Ill (R.B.L.); Department of Radiology and Radiological Sciences, Uniformed Services University of the Health Sciences, Bethesda, Md (R.B.L.); the Joint Pathology Center, Silver Spring, Md (A.K.M.); Department of Radiology, Hospital Clínico San Carlos, Madrid, Spain (P.R.); and Department of Radiology, Perelman School of Medicine at the University of Pennsylvania, Philadelphia, Pa (M.S.L.). Received March 20, 2013; revision requested April 17 and received May 17; accepted May 20. For this journal-based SA-CME activity, the authors P.R. and M.S.L. have disclosed financial relationships (see p 1106); the other authors, editor, and reviewers have no relevant relationships to disclose. **Address correspondence to** R.B.L. (e-mail: *rachellewis@acr.org*).

## Introduction

Esophageal neoplasms comprise a diverse spectrum of tumors in terms of clinical course, underlying pathologic features, and imaging manifestations. Esophageal cancer is an important cause of mortality, representing the eighth most common malignant tumor and sixth most common cause of cancer death worldwide (1). Benign esophageal tumors, while uncommon compared with esophageal carcinoma, can cause dysphagia and occasionally have dramatic clinical outcomes such as sudden death. Imaging is essential for detection, diagnosis, staging, and treatment planning of esophageal neoplasms.

In this article, we review the clinical characteristics, pathologic features, and imaging appearances of esophageal neoplasms with emphasis on radiologic-pathologic correlation. Esophageal tumors can be classified into epithelial neoplasms, nonepithelial neoplasms, and tumorlike lesions (Table). The most common benign and malignant neoplasms—leiomyoma, SCC, and adenocarcinoma—will be emphasized. Fibrovascular polyp, granular cell tumor, lymphoma, spindle cell carcinoma, neuroendocrine neoplasms, and other rare neoplasms are also discussed.

**Classification of Esophageal Neoplasms**

| |
|---|
| Epithelial neoplasms |
| SCC |
| SCC variants |
| Spindle cell carcinoma |
| Basaloid squamous carcinoma |
| Verrucous carcinoma |
| Squamous papilloma |
| Adenocarcinoma |
| Adenosquamous carcinoma |
| Adenoma |
| Neuroendocrine neoplasms |
| Salivary gland–type tumors |
| Adenoid cystic carcinoma |
| Mucoepidermoid tumor |
| Pleomorphic adenoma |
| Nonepithelial neoplasms |
| Leiomyoma |
| GIST |
| Sarcomas, particularly leiomyosarcoma |
| Lymphoma |
| Metastasis |
| Malignant melanoma |
| Granular cell tumor |
| Hemangioma |
| Schwannoma |
| Neurofibroma |
| Glomus tumor |
| Tumorlike lesions |
| Glycogenic acanthosis |
| Duplication cyst |
| Fibrovascular polyp |
| Inflammatory fibroid polyp |

Note.—GIST = gastrointestinal stromal tumor, SCC = squamous cell carcinoma.

## Benign Esophageal Neoplasms

Benign tumors represent 20% of esophageal neoplasms at autopsy (2). Since many of these tumors are small and do not cause symptoms, less than 1% of esophageal tumors that come to clinical attention are benign (3). General imaging findings of benign tumors include a smooth intramural or intraluminal mass without ulceration or nodularity at barium examination and absence of peritumoral invasion, lymphadenopathy, or distant metastases at cross-sectional imaging.

### Leiomyoma

Leiomyomas are neoplasms of mature smooth muscle cells and are the most common benign esophageal neoplasm, although they are about 50 times less common than esophageal carcinoma (4). They are also the most common mesenchymal tumor of the esophagus, unlike in the remainder of the gastrointestinal tract, where GISTs predominate.

Esophageal leiomyomas are nearly twice as common in men as in women and have been reported in patients between 4 and 81 years of age, although they rarely occur in the pediatric population (5,6). Most patients are asymptomatic, but dysphagia and pain may develop, depending on the size of the lesion and amount of encroachment on the esophageal lumen. Unlike patients with malignant esophageal tumors,

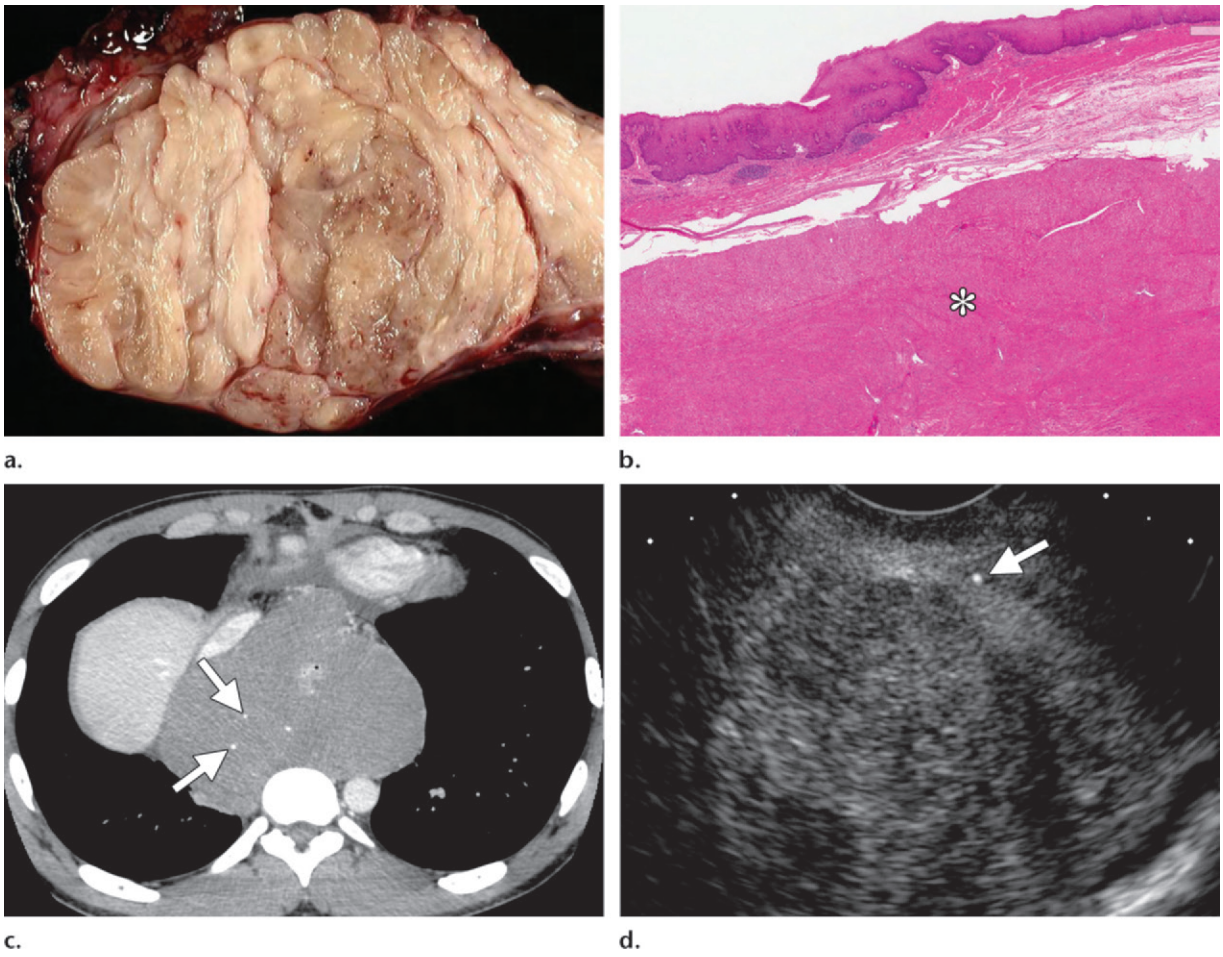



**Figure 1.** Esophageal leiomyoma in a 27-year-old man with an incidental mass found at chest radiography for tuberculosis screening. **(a)** Photograph of the sectioned gross specimen shows a tan lobular mass without necrosis. **(b)** Photomicrograph (scanning magnification, hematoxylin-eosin [H-E] stain) shows a well-demarcated lesion (*) composed of spindle-shaped smooth muscle cells that arises from the muscularis propria. **(c)** Axial contrast material–enhanced computed tomographic (CT) image shows a large esophageal mass with homogeneous attenuation and scattered punctate calcifications (arrows). **(d)** Image from endoscopic ultrasonography (US) shows a large hypoechoic mass with an echogenic focus (arrow), a finding compatible with a small area of calcification.

affected individuals usually have long-standing symptoms, with a duration of more than 2 years in most cases (4). Treatment options include endoscopic resection, surgical enucleation, and observation. Esophageal leiomyomas have a benign clinical course and typically do not recur after surgery.

***Pathologic Features.***—Leiomyomas are usually less than 3 cm in size and are found predominantly in the middle and lower thirds of the esophagus, the portion of the esophagus lined by smooth muscle (7). They appear grossly as smooth or slightly lobulated masses and have a whorled appearance (Figs 1, 2). Leiomyomas occasionally may contain dense areas of calcification, but cystic degeneration, necrosis, and ulceration almost never occur. These tumors may arise from the muscularis mucosae or muscularis propria layers of the esophageal wall; 97% are intramural, with 10% of these having a circumferential growth pattern (4).

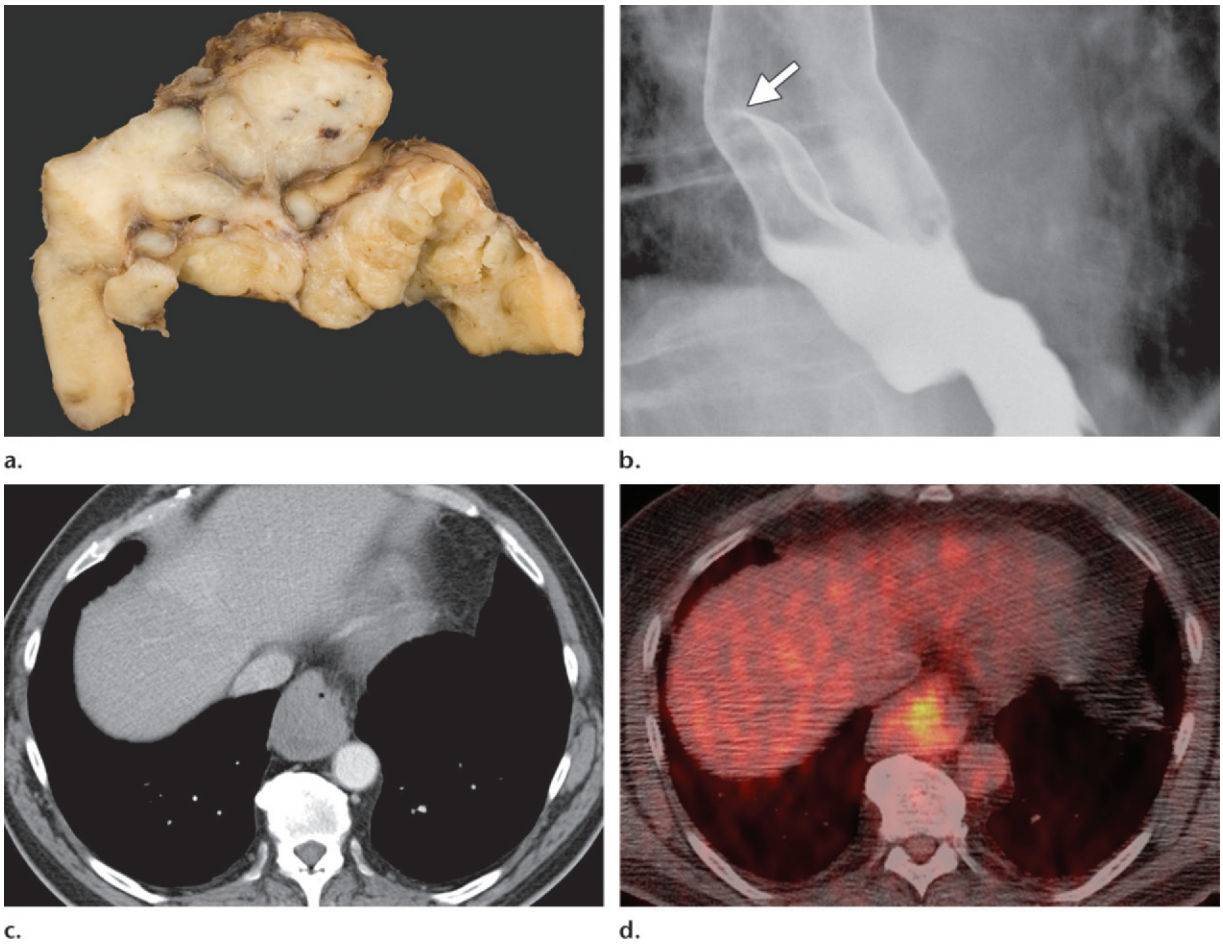



**Figure 2.** Esophageal leiomyoma in a 72-year-old man with a 3-month history of dysphagia. **(a)** Photograph of the sectioned gross specimen shows a tan nodular mass. **(b)** Spot image from double-contrast esophagography shows a smoothly marginated filling defect (arrow) that forms a slightly obtuse angle with the adjacent esophageal wall. This appearance is characteristic of a submucosal mass. **(c, d)** Axial contrast-enhanced CT **(c)** and fused positron emission tomographic (PET)/CT **(d)** images show a homogeneous soft-tissue–attenuation mass in the distal esophagus with avid uptake of fluorine 18 fluorodeoxyglucose (FDG).

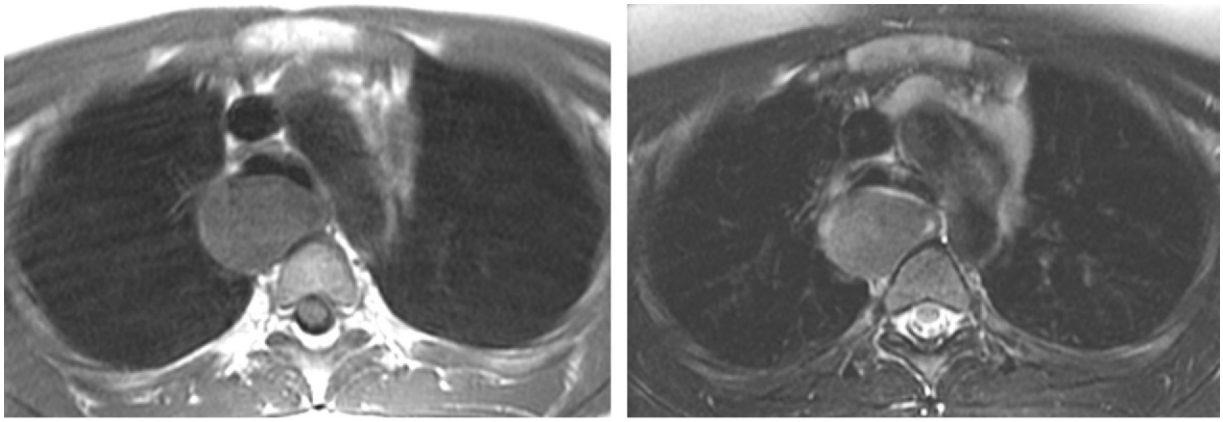
Microscopically, esophageal leiomyomas consist of an interlacing or palisading pattern of spindle cells with eosinophilic cytoplasm (Fig 1). The cells have a bland appearance without nuclear pleomorphism, and there is little to no mitotic activity. Fibrous tissue is intermingled, and areas of dense collagen can become calcified. Immunohistochemical analysis helps distinguish esophageal leiomyomas from GISTs, as the former are negative for CD117 and CD34.

***Imaging Features.***—Esophageal leiomyomas are sometimes seen as mediastinal masses at chest radiography, with an abnormal azygoesophageal line and occasional coarse calcification (8,9). At barium examination, leiomyomas exhibit the typical findings of an intramural mass, appearing as smooth-surfaced crescent-shaped filling defects that form right angles or slightly obtuse angles with the adjacent esophageal wall (Fig 2) (10). They can occasionally encircle the esophagus, producing a short stricture (8).

Teaching Point

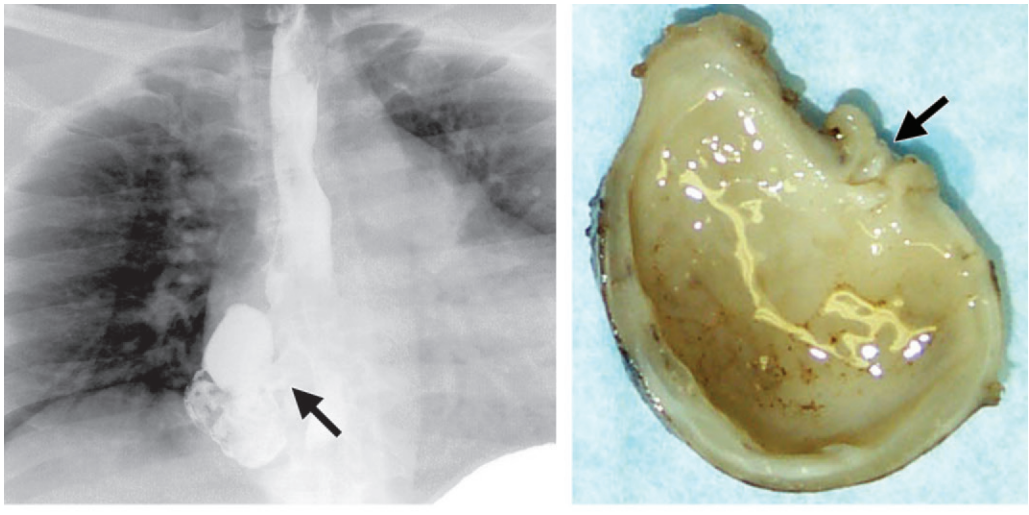
At cross-sectional imaging, esophageal leiomyomas are smoothly marginated homogeneous masses in the mid to lower esophagus, occasionally containing areas of calcification (Fig 1). These tumors are isoattenuating or hypoattenuating to muscle at nonenhanced CT and slightly hyperintense at T2-weighted magnetic resonance (MR) imaging (Fig 3). They demonstrate homogeneous enhancement without necrosis (8).

Endoscopic US can facilitate diagnosis and guide the treatment approach by demonstrating which layer of the esophageal wall is involved. Endoscopic US findings of a homogeneous hypoechoic mass in the muscularis mucosae, submucosa, or muscularis propria with an intact overlying mucosa have a diagnostic accuracy of 89% for esophageal leiomyoma (11). Results of FDG PET are usually negative in patients with



a. b.

**Figure 3.** Esophageal leiomyoma in a 14-year-old girl with a 5-year history of dysphagia. **(a)** Axial T1-weighted MR image shows a homogeneous midesophageal mass that is isointense to muscle. **(b)** On an axial T2-weighted MR image, the mass has homogeneous signal intensity that is slightly hyperintense to that of muscle.



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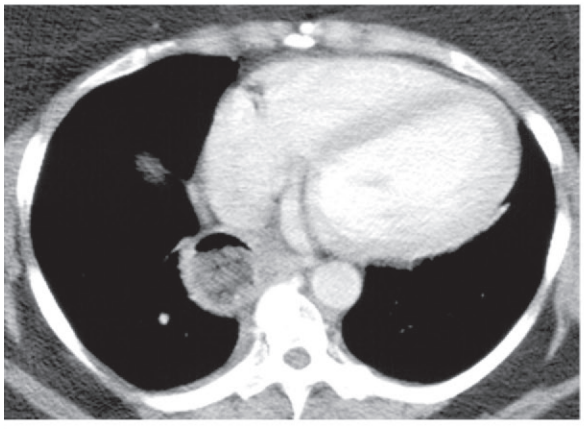
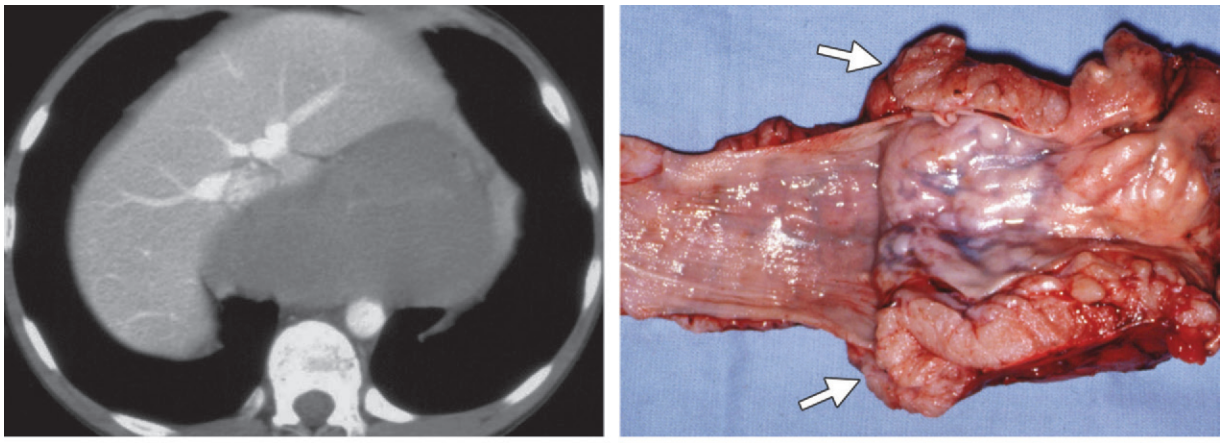


b.

**Figure 4.** Communicating esophageal duplication cyst in a 42-year-old woman with epigastric pain. **(a)** Spot image from double-contrast esophagography shows a barium- and air-filled outpouching with a narrow neck (arrow) that extends from the right lateral wall of the distal thoracic esophagus. **(b)** Axial contrast-enhanced CT image shows a paraesophageal mass containing debris and air. **(c)** Photograph of the sectioned gross specimen shows a thick-walled cyst with divided communication with the esophagus (arrow).

leiomyomas, as these tumors have a low mitotic rate, although uptake has occasionally been reported (Fig 2) (12).

The differential diagnosis for intramural lesions in the esophagus also includes duplication cysts, granular cell tumors, GISTs, lymphoma, and hematogenous metastases. Duplication cysts are the second most common benign esophageal lesions after leiomyomas, but usually manifest in childhood and have typical findings of cysts with all imaging modalities. Rarely, duplication cysts may communicate with the esophageal lumen (Fig 4). Granular



a. b.

**Figure 5.** Esophageal leiomyomatosis in a 15-year-old boy with Alport syndrome and a 1-year history of worsening dysphagia. **(a)** Axial contrast-enhanced CT image shows marked circumferential thickening of the lower thoracic esophagus extending to the gastroesophageal junction. **(b)** Photograph of the sectioned gross specimen shows abrupt enlargement of the muscular layer of the esophageal wall (arrows) with a tan, whorled cut surface.

cell tumors of the esophagus may be indistinguishable from leiomyomas but are much less common and tend to be multiple (13).

Calcification has been reported to be a specific finding of leiomyomas but can also occur in esophageal GISTs (14,15). Large GISTs may be differentiated by central low attenuation secondary to necrosis or cyst formation. Small GISTs may be homogeneous intramural masses indistinguishable from leiomyomas; however, small leiomyomas are relatively more common. In a study of small incidental mesenchymal tumors, 80 esophageal leiomyomas were identified compared with nine esophageal GISTs (16). Esophageal lymphoma and metastatic disease usually occur in the setting of contiguous invasion or widespread disease (7).

***Esophageal Leiomyomatosis.***—There are rare cases of diffuse proliferation of smooth muscle in the wall of the esophagus that is indistinguishable pathologically from the appearance of multiple leiomyomas; this entity has been described as leiomyomatosis. Esophageal leiomyomatosis can be familial, occurring in patients with Alport syndrome, where it is related to a germline deletion of collagen IV subunit genes on the X chromosome (7). Leiomyomatosis can also occur as an isolated condition or can be associated with leiomyomas of the tracheobronchial tree and genital tract. This condition usually manifests in childhood or early adulthood.

Marked homogeneous thickening of the distal esophageal wall is seen at CT (Fig 5) and MR imaging, with tapered narrowing of the distal esophagus at barium esophagography (17,18). This appearance can mimic achalasia at barium examination, but the thickened distal esophageal wall may extend across the gastroesophageal junction, producing a pair of smooth indentations on the adjacent gastric fundus, a finding suggestive of the correct diagnosis (17).

## Fibrovascular Polyp

Fibrovascular polyps are intraluminal esophageal polyps that consist of varying proportions of fibrous and adipose tissue with associated blood vessels. Because of these pathologic components, fibrovascular polyps have also been referred to as hamartomas, lipomas, fibromas, fibrolipomas, fibromyxomas, and fibroepithelial polyps. It is widely held that they result from loose submucosal tissue in the Laimer triangle, just inferior to the cricopharyngeus, that elongates over time from peristalsis.

Fibrovascular polyps represent only approximately 1%–2% of benign esophageal tumors, but are widely known for a rare but spectacular form of clinical presentation when these polyps are regurgitated into the pharynx or even the mouth (Fig 6), with possible asphyxia and sudden death

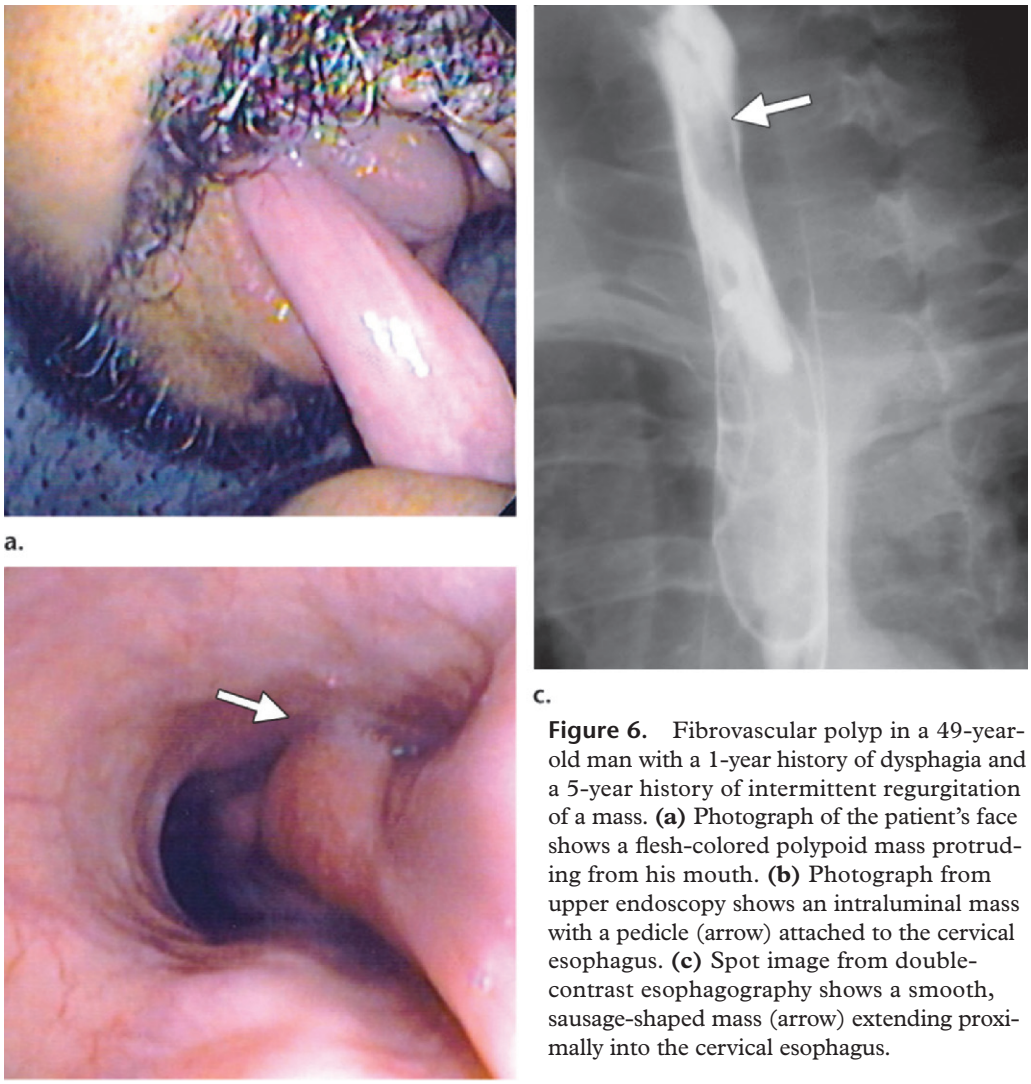


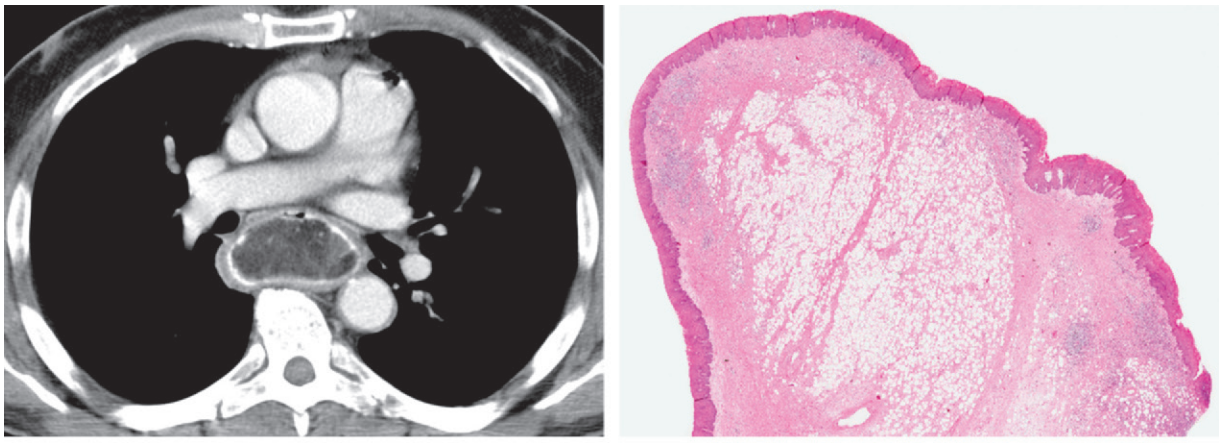
**Figure 6.** Fibrovascular polyp in a 49-year-old man with a 1-year history of dysphagia and a 5-year history of intermittent regurgitation of a mass. **(a)** Photograph of the patient's face shows a flesh-colored polypoid mass protruding from his mouth. **(b)** Photograph from upper endoscopy shows an intraluminal mass with a pedicle (arrow) attached to the cervical esophagus. **(c)** Spot image from double-contrast esophagography shows a smooth, sausage-shaped mass (arrow) extending proximally into the cervical esophagus.

(19). In a review of 75 patients, there was a slight male preponderance and an average age of 53 years, with a range of 1–88 years. Dysphagia was the most common presenting symptom, found in 69% of patients, followed by regurgitation of the polyp, a foreign-body sensation, and respiratory symptoms ranging from cough to respiratory distress (20). Rarely, ulceration of the tip of the polyp can cause bleeding.

Surgical removal is recommended to treat the symptoms and avoid the risk of sudden death. Recurrence has been reported in about 10% of patients, and there are sporadic descriptions of malignant transformation to SCC, adenocarcinoma, or sarcoma (20,21).

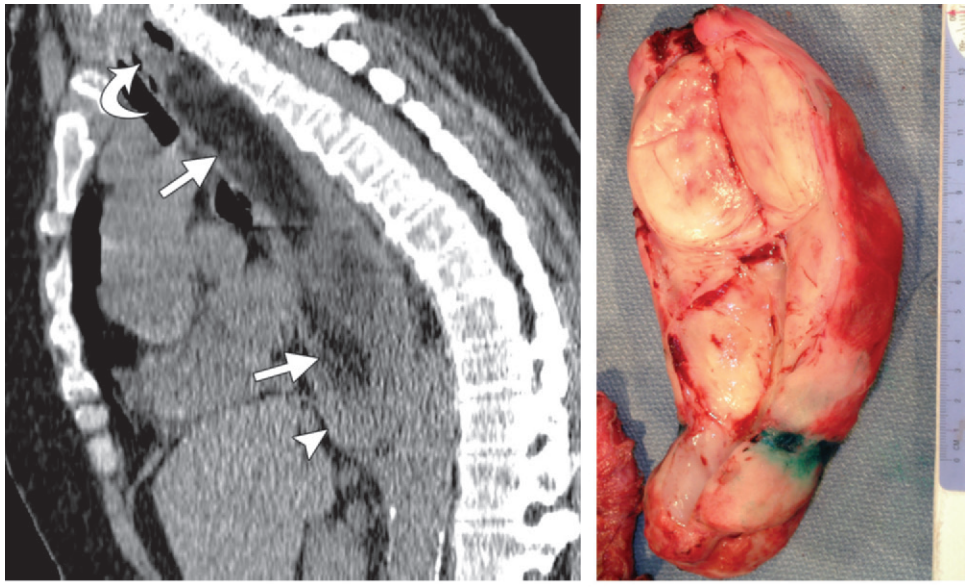
***Pathologic Features.***—Fibrovascular polyps appear grossly as elongated intraluminal masses that originate from the cervical esophagus near the level of the cricopharyngeus (Fig 6) or occasionally from the lower hypopharynx. Most of these polyps are 7 cm or longer at the time of presentation and can extend as far as 20 cm into the distal esophagus, occasionally traversing the gastroesophageal junction to enter the gastric fundus (22).

At pathologic examination, fibrovascular polyps have a white myxoid appearance mixed with yellow adipose tissue. Microscopic examination reveals varying amounts of adipose tissue and loose or dense fibrovascular tissue, covered by normal squamous epithelium (Fig 7).



a. b.

**Figure 7.** Fibrovascular polyp in a 64-year-old man with a 6-year history of dysphagia. **(a)** Axial contrast-enhanced CT image shows an intraluminal esophageal mass with predominantly fat attenuation. **(b)** Photomicrograph (scanning magnification, H-E stain) shows esophageal squamous mucosa with submucosal expansion by fibroadipose tissue and chronic inflammatory cells.



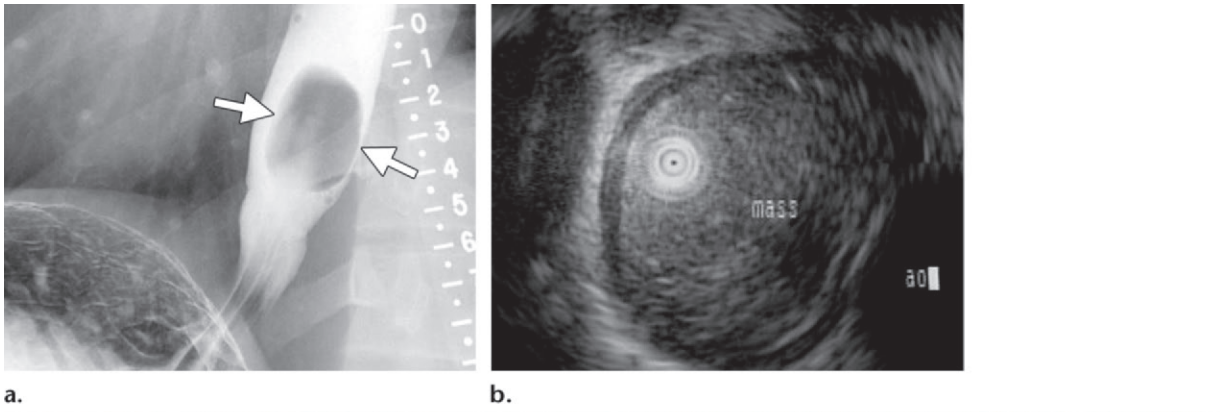
a. b.

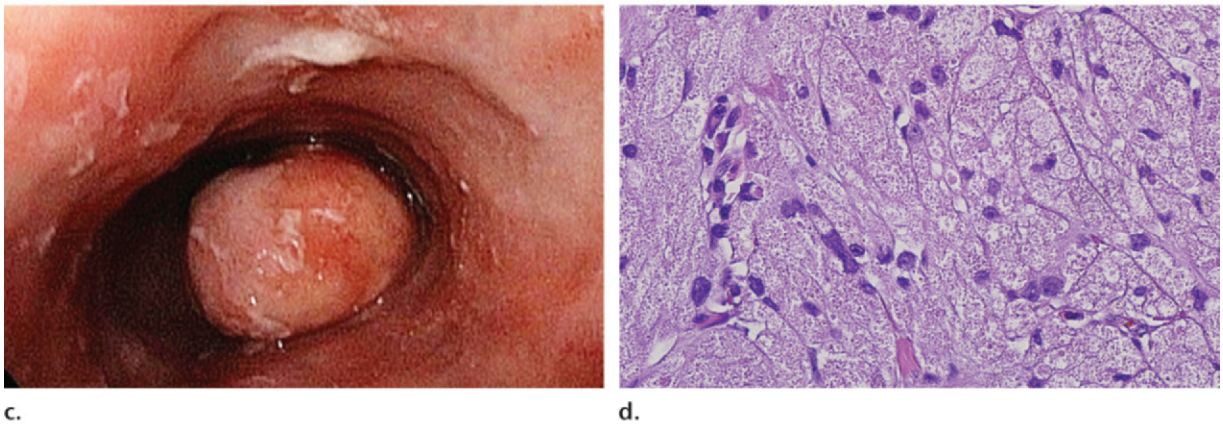
**Figure 8.** Fibrovascular polyp in a 60-year-old man with a history of dysphagia. **(a)** Sagittal nonenhanced CT image shows a long polypoid mass with fat (straight arrows) and soft-tissue (arrowhead) components. The pedicle (curved arrow) extends to the cervical esophagus. **(b)** Photograph of the sectioned gross specimen shows a nodular, tan-yellow cut surface. The mass extended into the stomach, with the location of the gastroesophageal junction marked in green.

***Imaging Features.***—At chest radiography, fibrovascular polyps may manifest as lobulated superior right-sided mediastinal masses on frontal views and retrotracheal masses with anterior deviation of the trachea on lateral views (23). At barium examination, a sausage-shaped intraluminal mass originating from the cervical esophagus is characteristic, although the proximal pedicle is usually not identified (Fig 6) (23). The polyp may extend inferiorly as far as the upper, middle, or distal esophagus or even into the stomach (Fig 8), depending on its length (23,24).

Teaching Point

The cross-sectional appearance of fibrovascular polyps depends on the proportions of fat and fibrous tissue in these lesions. A heterogeneous appearance may be seen, with areas of fat attenuation, hyperechogenicity, or high T1 signal from adipose tissue mixed with areas of soft-tissue attenuation, hypoechogenicity, or low T1 signal from fibrovascular tissue, or one component may predominate (Figs 7, 8) (23,25,26). Punctate calcification has occasionally been noted at CT (23,27).



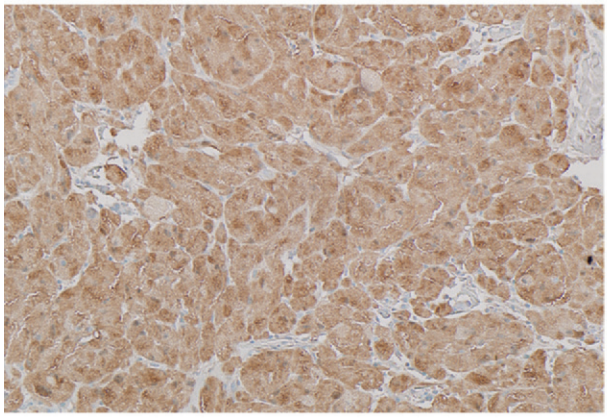




**Figure 9.** Granular cell tumor in a 20-year-old man with a 3-year history of dysphagia. **(a)** Spot image from single-contrast esophagography shows a smoothly marginated filling defect (arrows) in the lower esophagus. **(b)** Endoscopic US image shows an oval hypoechoic mass arising from the submucosa. **(c)** Photograph from upper endoscopy shows a submucosal mass and mild esophagitis. **(d)** Photomicrograph (original magnification, ×40; H-E stain) shows a nested pattern of polygonal cells filled with eosinophilic cytoplasmic granules. **(e)** Photomicrograph (original magnification, ×10; S-100 stain) shows diffuse nuclear and cytoplasmic positivity of the tumor cells.

## Granular Cell Tumor

Described by Abrikossoff in 1926 (28), granular cell tumors are rare neoplasms originating from Schwann cells. They were formerly thought to have muscle derivation and therefore called granular cell myoblastomas. Granular cell tumors are most commonly found in the skin, subcutaneous tissue, and tongue. Approximately 5%–8% arise in the gastrointestinal tract, and one-third of these tumors arise in the esophagus (13,29).

Granular cell tumors have a slight female predominance and can occur at any age, most commonly in the 5th decade (30). The vast majority of esophageal granular cell tumors are small tumors discovered incidentally at autopsy or endoscopy (29,31). Larger lesions occasionally may cause dysphagia.

Although most granular cell tumors have a clinically indolent course, it is estimated that 1%–3% are malignant, with a 5-year survival rate of less than 35% (32). In a literature review of 200 cases of esophageal granular cell tumors, three were found to be malignant (32). Given the scarcity of these tumors, there is no consensus on treatment, but some authors suggest endoscopic or surgical excision unless the lesion is less than 1 cm in size and causes no symptoms, in which case endoscopic surveillance is recommended (30).

***Pathologic Features.***—Most granular cell tumors are found in the distal esophagus and are less than 2 cm in diameter. They are yellow-white firm masses that are usually submucosal (Fig 9).

Multiplicity is relatively common; about 10% of patients with esophageal granular cell tumors have multiple esophageal lesions and 9%–16% have involvement of the esophagus and another organ, such as the tongue (29,31).

Microscopically, granular cell tumors are composed of nests of ovoid or polygonal cells separated by collagen bundles (Fig 9). The cells have abundant cytoplasm filled with eosinophilic granules, which are periodic acid–Schiff stain positive and diastase-resistant and have been determined to be autophagic vacuoles containing cellular debris (31). The Schwann cell derivation of the tumor cells can be confirmed with staining for S-100 (Fig 9). The overlying epithelium is intact but may be hyperplastic.

***Imaging Features.***—At barium examination, the typical appearance of a granular cell tumor is a small submucosal mass in the distal esophagus (Fig 9) (13). Endoscopic US may reveal a homogeneous hypoechoic mass that mimics a leiomyoma (Fig 9). Limited reports of the CT appearance of granular cell tumor include a moderately enhancing soft-tissue mass that partially narrows the esophageal lumen and thickening of the esophageal wall (30,33).

At MR imaging, an esophageal granular cell tumor was reported to have low T1 signal intensity and slightly high T2 signal intensity and to enhance homogeneously (34). Granular cell tumors at other sites have been described as having variable T2 signal intensity and enhancement patterns that appear to be related to variable cellularity and collagen content (35).

## Other Benign Esophageal Neoplasms

Mucosal-based benign neoplasms in the esophagus include squamous papillomas and adenomas. Squamous papillomas are typically found as incidental solitary polyps in the esophagus, with an average size of 4 mm (36). Their appearance cannot be distinguished from that of a polypoid early esophageal carcinoma (10). Infrequently, multiple conglomerate lesions of papillomatosis can be found throughout the esophagus (Fig 10). Adenomas are rare sessile or pedunculated polyps that arise in Barrett esophagus, necessitating resection because of the risk of malignant transformation (10).

Other than leiomyomas, benign intramural neoplasms of the esophagus, such as hemangiomas, schwannomas, neurofibromas, and glomus tumors, are extremely rare.

# Malignant Esophageal Neoplasms

Approximately 80% of esophageal neoplasms are malignant. More than 90% of these are SCCs or adenocarcinomas, although the relative proportion differs by geographic location. General imaging findings of malignancy include a stricture or mass with mucosal irregularity or ulceration at barium esophagography and evidence of tumor spread with infiltration of the periesophageal fat, lymphadenopathy, or distant metastases at cross-sectional imaging.

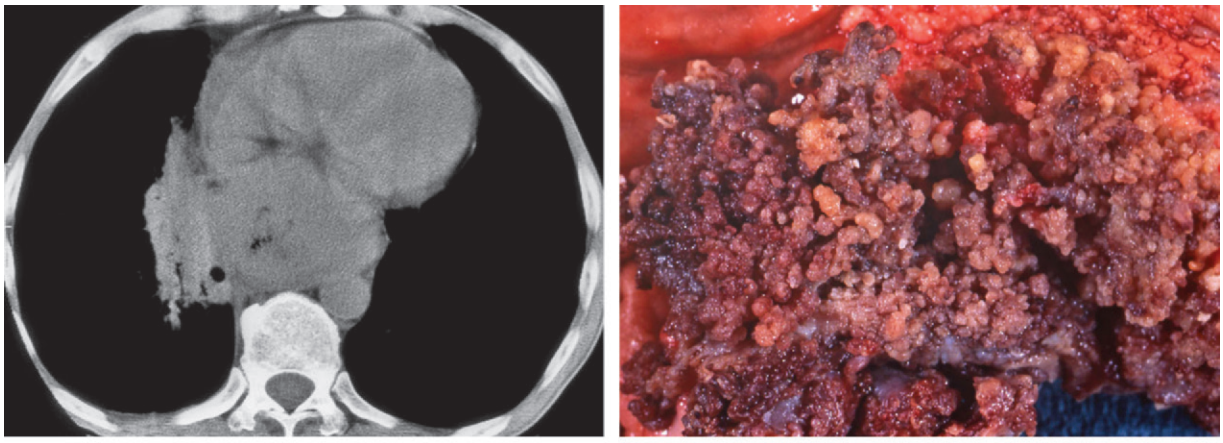
Teaching Point

Given the overlapping imaging features of esophageal malignancies, the main role of radiology is staging. Esophageal carcinoma is staged by using the TNM classification, which was updated by the American Joint Committee on Cancer in 2009 and includes tumors of the stomach centered within 5 cm of the gastroesophageal junction that extend into the esophagus (37).

## Squamous Cell Carcinoma

SCC is a malignant tumor of epithelial cells with stratified squamous differentiation that progresses from precursor lesions of intraepithelial neoplasia (38). It is the most common esophageal neoplasm worldwide, although its prevalence in the United States has been decreasing over the past several decades, most likely as a result of declining tobacco consumption (39).

SCC of the esophagus is more common in men than in women and its prevalence increases with age: Approximately 65% of patients are men, and the peak age group is 60–74 years of age (40). There is striking ethnic and geographic variation. In the United States, black men are at highest risk, with a rate of SCC four times that of white men (39). Esophageal cancer is most common in east-



a. b.

**Figure 10.** Esophageal papillomatosis in a 59-year-old man with increasing dysphagia and weight loss. **(a)** Axial nonenhanced CT image shows diffuse asymmetric thickening of the lower esophageal wall. The consolidation in the right lower lobe is likely postobstructive. **(b)** Photograph of the gross specimen shows a conglomerate mass of papillary projections.

ern and southern Africa and eastern Asia, where more than 20 cases per 100,000 people have been reported, in comparison with 1.8 cases per 100,000 people in the United States (1,40).

Tobacco and alcohol use are the major risk factors for SCC of the esophagus in the United States and appear to have a synergistic effect in increasing the risk of cancer. Other risk factors include a diet low in fresh fruit and vegetables or high in nitrosamines, achalasia, celiac disease, acid or lye burns, and Plummer-Vinson syndrome (characterized by the triad of dysphagia, iron-deficiency anemia, and upper esophageal webs). A genetic predisposition exists in patients with tylosis, a rare hereditary condition caused by a defect in the tylosis esophageal cancer gene on chromosome 17q25 (7).

Progressive dysphagia, odynophagia, and weight loss are the most common symptoms of SCC of the esophagus (41). Patients with mediastinal tumor invasion may have chest pain unrelated to swallowing. Unfortunately, symptomatic patients usually have advanced disease at the time of diagnosis (41). Superficial cancers, defined as tumors limited to the mucosa or submucosa, regardless of lymph node status (T1 cancers), cause no symptoms in more than 85% of patients (42).

The overall prognosis is dismal, with a 5-year survival rate of only about 10% (7). The most important prognostic factor is the extent of tumor at the time of diagnosis, including the depth of invasion and lymph node status. Invasion limited to the mucosa is associated with a 5-year survival rate of more than 80% and can potentially be treated with endoscopic resection (42). However, most symptomatic patients have involvement of the periesophageal tissue or lymph nodes with a 5-year survival rate of less than 5% (43).

***Pathologic Features.***—The majority of SCCs involve the middle third of the esophagus, followed by the lower third and then the upper third. These tumors can exhibit a variety of gross morphologic patterns, appearing as polypoid, flat, or ulcerated lesions. The Japanese Esophageal Society has classified the macroscopic appearance of esophageal carcinoma for superficial lesions (types 0-I through 0-III, limited to the mucosa or submucosa) and advanced lesions (types 1–5, extending into or beyond the muscularis propria), similar to the classification

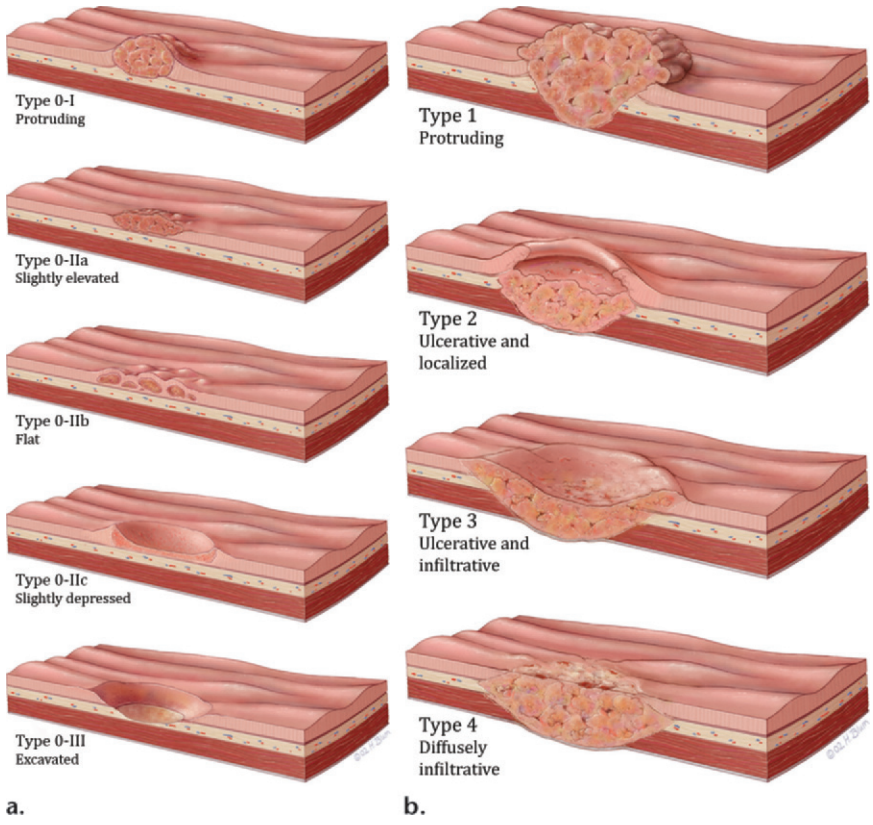



**Figure 11.** Japanese Esophageal Society macroscopic classification of esophageal and gastric cancer. **(a)** Type 0 is superficial, limited to the mucosa and submucosa, and may be protruding (type 0-I), slightly elevated (type 0-IIa), flat (type 0-IIb), slightly depressed (type 0-IIc), or excavated (type 0-III). **(b)** Types 1–5 are advanced, extending beyond the submucosa, and may be protruding (type 1), ulcerative and localized (type 2), ulcerative and infiltrative (type 3), or diffusely infiltrative (type 4). Type 5 is unclassifiable. (Fig 11a and 11b courtesy of Heike Blum, Muenster, Germany.)

for gastric carcinoma (Fig 11) (44). Advanced lesions are usually infiltrating (Fig 12) but can also be polypoid, fungating, or ulcerative (38). Superficial SCCs are most commonly flat, plaquelike, or slightly elevated (42).

Histologically, nests of squamous epithelial cells penetrate beyond the epithelial basement membrane with little desmoplastic response (Fig 12). Well-differentiated tumors contain extensive keratinization, with cells that have eosinophilic cytoplasm and intercellular bridges. The amount of keratinization decreases and the proportion of basaloid cells increases as tumors become more poorly differentiated. Most esophageal SCCs are moderately differentiated, but tumor grade does not seem to affect the prognosis (7).

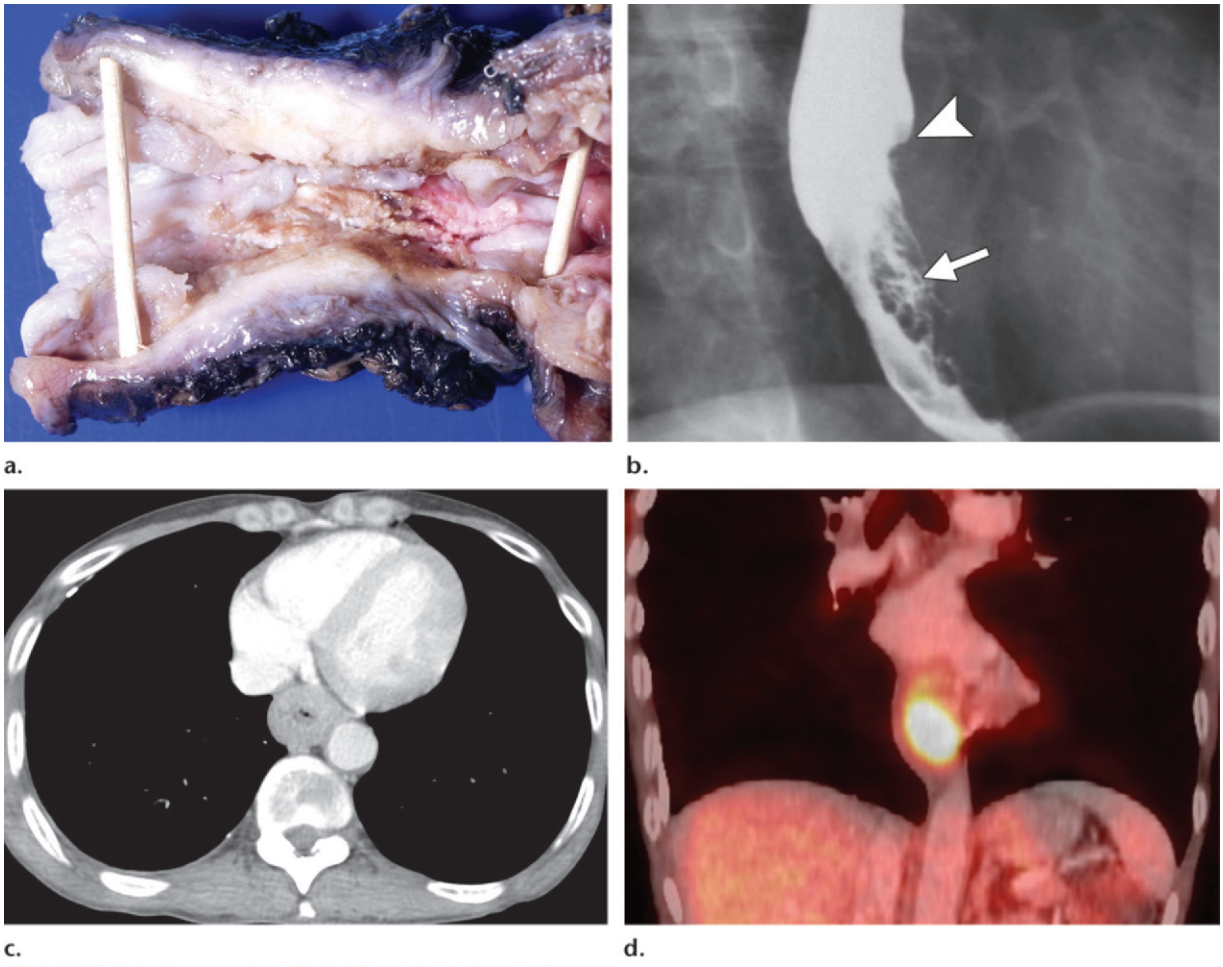
As SCC invades the esophageal wall, it gains access to lymphatic vessels in the lamina propria and submucosa. As a result, intramural metastases are found in up to 16% of patients (7). In the muscularis propria, SCC follows the direction of the muscle fibers, extending first circumferentially in the inner layer and then longitudinally in the outer layer. Once outside the muscularis propria, spread to adjacent tissues or organs is common.

***Imaging Features.***—While not a primary imaging modality for esophageal disease, chest radiography may be performed during evaluation of chest complaints. According to a study of 103 patients with esophageal cancer by Lindell et al (45), the most sensitive findings at chest radiography were an abnormal azygoesophageal line convex to the right in 27% of cases, a widened retrotracheal stripe greater than 3–4 mm in width in 11%, and tracheal deviation in 10%, but at least 50% of patients had no findings attributable to their disease (45).

Most SCCs of the esophagus detected at barium esophagography are advanced tumors at the time of diagnosis, appearing as infiltrative lesions with irregular luminal narrowing, ulceration, and abrupt shouldered margins (Fig 12) (41,46,47). Primarily ulcerative, polypoid, and varicoid appearances are less common. Superficial SCCs can demonstrate plaquelike, polypoid, or ulcerative appearances but can also be quite subtle, with poorly defined nodules that merge with one another, producing a confluent area of disease (41). Elevated lesions and rigidity of the esophageal wall have been shown to correlate with submucosal extension of tumor (42).

At CT, esophageal cancer causes localized thickening of the esophageal wall or a soft-tissue mass. Wall thickening may be asymmetric in

**Figure 12.** SCC of the esophagus in a 51-year-old man with a 3-month history of progressive dysphagia and a 20-lb (9-kg) weight loss. **(a)** Photograph of the bivalved gross specimen shows infiltrative growth expanding the wall of the distal esophagus and extending into but not through the muscular layer. **(b)** Spot image from double-contrast esophagography shows an irregular stricture in the distal esophagus with areas of ulceration (arrow) and a shelflike proximal margin (arrowhead). **(c)** Axial contrast-enhanced CT image shows concentric thickening of the esophageal wall. **(d)** Coronal fused PET/CT image shows marked uptake by the esophageal primary tumor without evidence of distant metastasis. **(e)** Photomicrograph (original magnification, ×10; H-E stain) shows nests of atypical squamous cells (arrows) invading the submucosa.

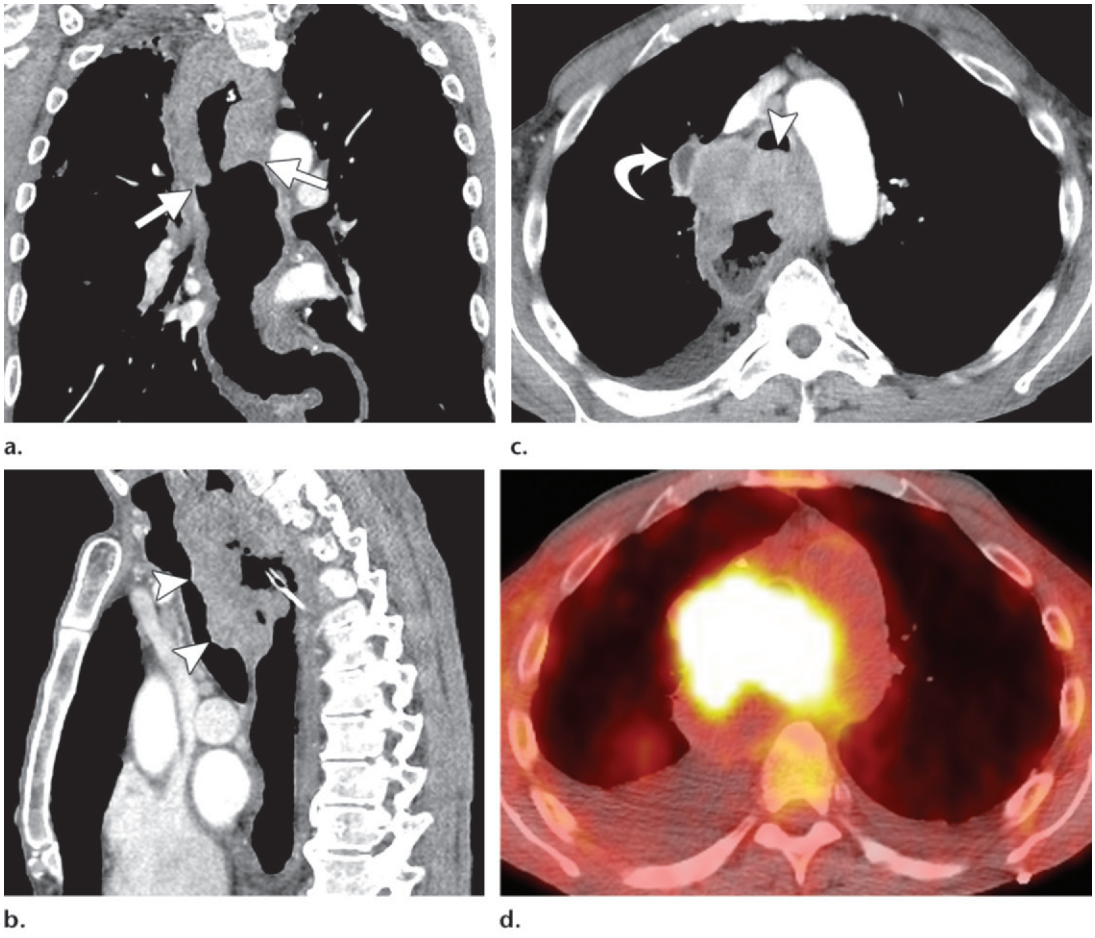



early esophageal cancer and progress to circumferential involvement (Fig 12) (48). In a study of dynamic contrast-enhanced CT by Umeoka et al (49), esophageal SCC demonstrated peak enhancement in the late arterial phase (35 seconds) compared with more gradual enhancement of the normal esophagus; all 30 SCCs were identified in this phase, including eight T1 lesions, only two of which were also identified in the venous phase.

CT plays an important role in staging of esophageal cancer, especially in evaluating mediastinal invasion and distant metastatic disease, and may show complications, such as esophageal obstruction and tracheoesophageal fistula formation. Features of mediastinal invasion include loss of intervening fat planes and displacement or indentation of the trachea (Fig 13) or other mediastinal structures. Contact of the tumor with 90° or more of the aortic circumference is worrisome for aortic invasion (Fig 14) (50). CT is sensitive for detection of distant

Teaching Point

**Figure 13.** SCC of the esophagus in a 67-year-old man with achalasia and a 4-month history of unintentional 30-lb (13.5-kg) weight loss. **(a)** Coronal contrast-enhanced CT image shows marked thickening of the upper thoracic esophageal wall with an abrupt transition inferiorly (arrows). The esophagus is otherwise diffusely dilated from achalasia. **(b, c)** Sagittal **(b)** and axial **(c)** contrast-enhanced CT images show displacement and indentation of the trachea (arrowheads), findings consistent with tracheal invasion. An involved lymph node (arrow in **c**) shows peripheral enhancement from central necrosis. **(d)** Axial fused PET/CT image shows avid uptake by the esophageal carcinoma obscuring the involved lymph node. **(e)** Photograph of the gross specimen shows a fungating carcinoma projecting into the esophageal lumen.

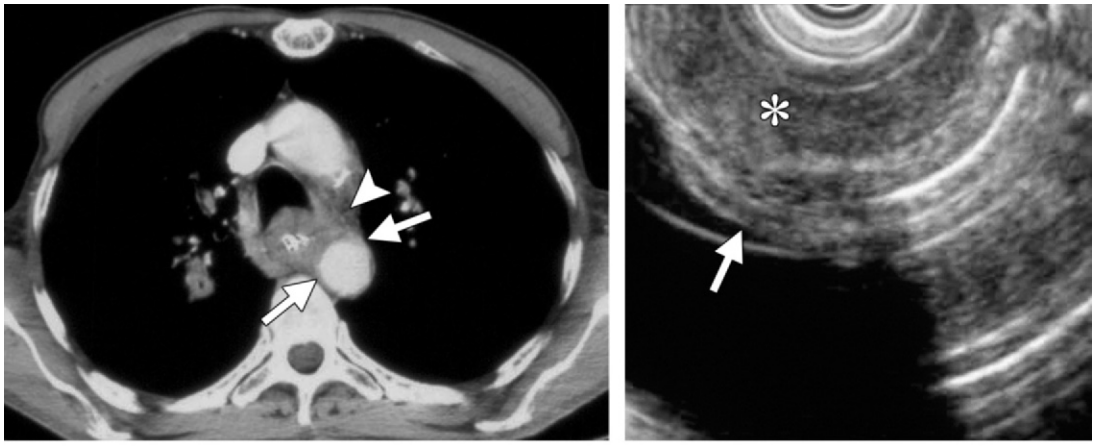



metastases, most commonly involving the liver, lungs, and bones; however, CT is less sensitive for detecting nodal metastases, as involved lymph nodes often are not enlarged (50).

At endoscopic US, esophageal carcinoma is characterized by the presence of a homogeneous or heterogeneous hypoechoic mass (Fig 14). The depth of invasion is determined by the extent of disruption of the esophageal wall, beginning at the mucosa and progressing through its various layers (51). Features suggestive of lymph node involvement include a diameter greater than 1 cm, homogeneous hypoechogenicity, a rounded shape, and sharp borders (52).

Compared with other imaging modalities, endoscopic US better demonstrates the depth of invasion in the esophageal wall, allowing distinction between T1, T2, and T3 disease (tumor invasion of the mucosa or submucosa, muscularis propria,

**Figure 14.** SCC of the esophagus in a 63-year-old man with a 2-month history of dysphagia and weight loss. **(a)** Axial contrast-enhanced CT image shows concentric thickening of the esophageal wall. Contact of the tumor with greater than 90° of the aortic circumference (arrows) is concerning for aortic invasion, and stranding of the adjacent fat (arrowhead) is consistent with mediastinal invasion. **(b)** Endoscopic US image shows a hypoechoic mass (*) that extends from the esophageal wall to invade the aorta (arrow).




and adventitia, respectively) with an accuracy of 84% (53). Endoscopic US is also better for evaluating regional lymph nodes, with a reported accuracy of 92% when combined with fine-needle aspiration (52). However, stenotic tumors may not allow passage of the echoendoscope in up to 50% of patients (54).

At MR imaging, esophageal carcinoma demonstrates intermediate T2 signal intensity, but fibrosis from neoadjuvant treatment may produce a similar appearance (55). Although not a primary modality for staging, MR imaging has been reported to be comparable to CT in determining various parameters of resectability, including mediastinal invasion, lymph node involvement, and distant metastases (56).

In general, SCC of the esophagus and its metastases display avid uptake at FDG PET (Fig 12). Pitfalls include uptake in regional lymph nodes obscured by the activity of the primary tumor (Fig 13) as well as lack of uptake in esophageal carcinoma confined to the mucosa or microscopic malignant foci in lymph nodes (57,58). The primary role of PET/CT is detection of distant metastases. In up to 20% of patients, FDG PET prevents unnecessary surgery by demonstrating metastatic disease not found with conventional modalities (57).

## Adenocarcinoma

Esophageal adenocarcinoma is a malignant epithelial neoplasm that almost always arises from malignant degeneration of underlying Barrett epithelium. Barrett esophagus is a premalignant condition in which there is replacement of the normal stratified squamous epithelium in the esophagus by columnar epithelium as a result of chronic gastroesophageal reflux and reflux esophagitis. Rarely, adenocarcinoma can also arise from heterotopic mucosa in the upper esophagus at or near the thoracic inlet.

Adenocarcinoma is the second most common malignant tumor of the esophagus in most countries. However, the incidence of esophageal adenocarcinoma has increased dramatically in some western countries over the past several decades, including the United States, where it now surpasses SCC as the predominant histologic type of esophageal cancer (40).

Approximately 85% of patients are men, and the peak incidence is in the 7th decade. In contrast to SCC of the esophagus, esophageal adenocarcinoma is about five times more common in white men than in black men (39). Barrett esophagus is by far the most important risk factor for development of esophageal adenocarcinoma. Tobacco consumption and obesity are additional risk factors.

Since most patients with Barrett esophagus are asymptomatic, the true frequency of adenocarcinoma is unknown; however, recent studies suggest a lower incidence than previously thought. A study in Denmark that followed up more than 11,000 patients with Barrett esophagus reported an annual risk of adenocarcinoma of only 0.12% and suggested screening only for patients with dysplasia at baseline endoscopy (59).

Patients with early esophageal adenocarcinoma are either asymptomatic or have symptoms from their underlying gastroesophageal

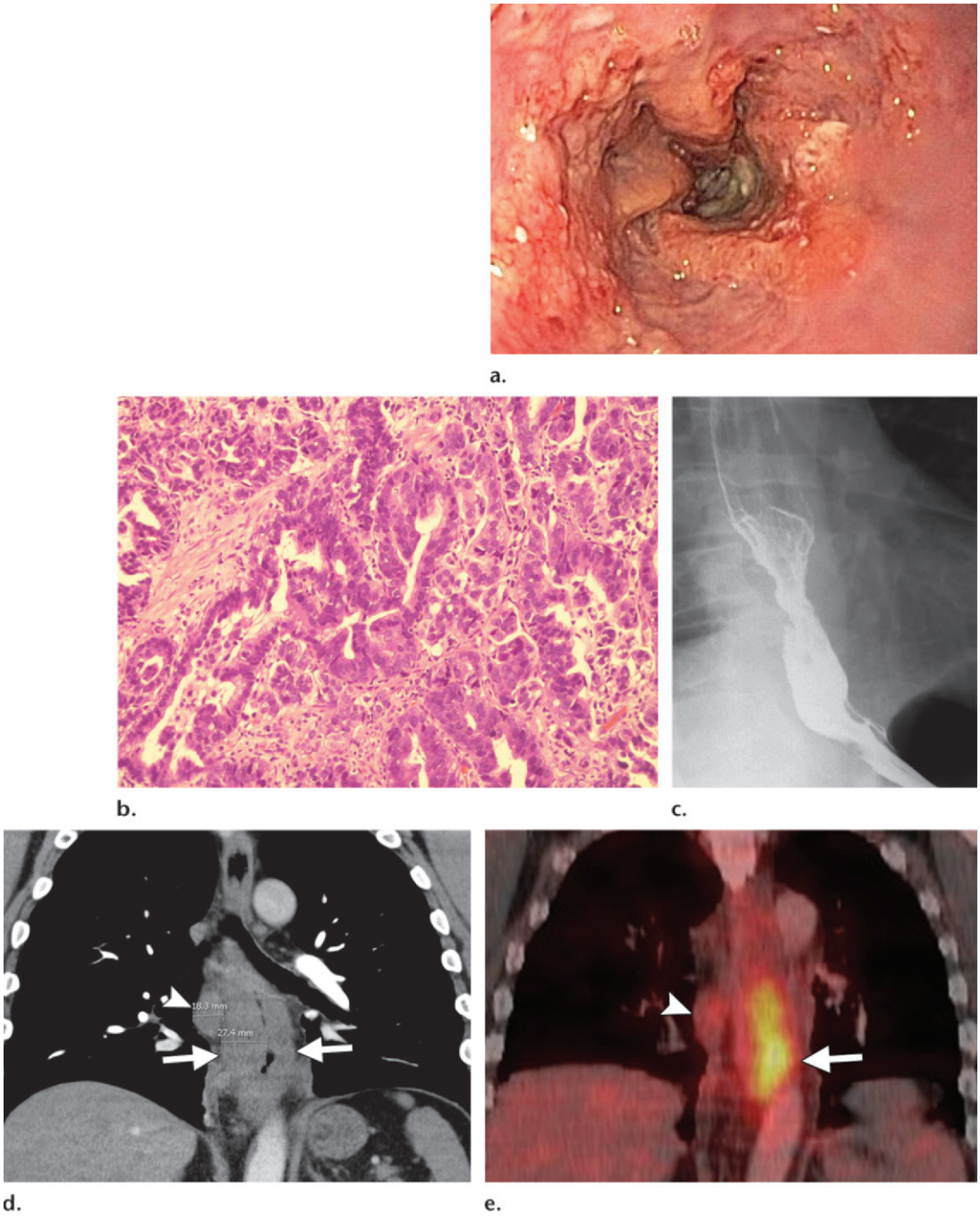



**Figure 15.** Esophageal adenocarcinoma in a 62-year-old man with a 3-month history of dysphagia and a 20-lb (9-kg) weight loss. **(a)** Photograph from upper endoscopy shows an irregular stenosis with diffuse nodularity on a background of Barrett esophagus. **(b)** Photomicrograph (original magnification, ×20; H-E stain) shows a tubulopapillary appearance of columnar cells with eosinophilic cytoplasm. **(c)** Spot image from double-contrast esophagography shows an irregular stricture in the distal esophagus that extends to the gastroesophageal junction. **(d, e)** Coronal contrast-enhanced CT **(d)** and fused PET/CT **(e)** images show diffuse wall thickening of the distal esophagus (arrows) and an enlarged periesophageal lymph node (arrowhead) with FDG uptake.

reflux disease (41). Most patients have advanced disease at the time of clinical presentation, and symptoms are similar to those in patients with advanced SCC. The prognosis depends primarily on the depth of invasion and the presence or absence of lymph node involvement. Independent of staging, esophageal adenocarcinoma has a better prognosis than SCC, with a 5-year survival rate after resection of 42% compared with 30% for SCC (60).

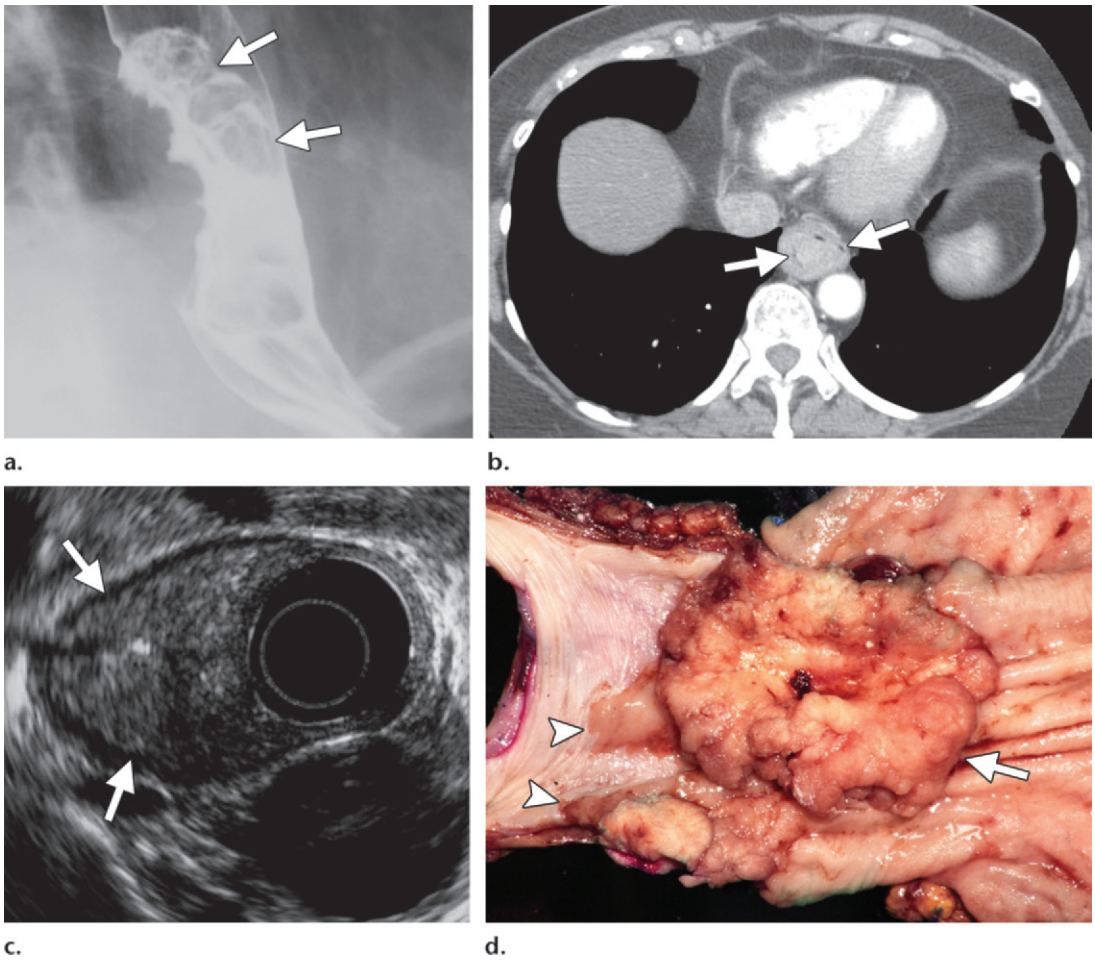


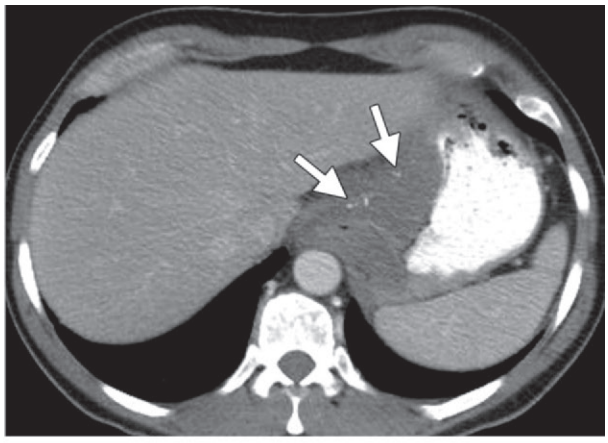

**Figure 16.** Esophageal adenocarcinoma in a 59-year-old woman with a long-standing history of gastroesophageal reflux disease and a 1-month history of dysphagia and odynophagia. **(a)** Image from double-contrast esophagography shows a polypoid lesion (arrows) in the distal esophagus with scalloped borders and mucosal irregularity. **(b)** Axial contrast-enhanced CT image shows a mass projecting into the esophageal lumen (arrows). The mass is outlined by foci of air. **(c)** Endoscopic US image shows a hypoechoic mass (arrows) involving the mucosa through the muscularis propria. **(d)** Photograph of the gross specimen shows a fungating intraluminal mass (arrow) near the gastroesophageal junction. Note the areas of tan mucosa in the distal esophagus (arrowheads), a finding consistent with Barrett esophagus.

***Pathologic Features.***—Because esophageal adenocarcinomas arise from preexisting Barrett mucosa, these tumors are usually located in the lower third of the thoracic esophagus. Unlike SCCs, esophageal adenocarcinomas have a marked tendency to invade the gastric cardia and fundus by direct extension across the gastroesophageal junction (61). Most esophageal adenocarcinomas appear grossly as infiltrating (Fig 15), polypoid (Fig 16), or ulcerative lesions (62).

Esophageal adenocarcinomas develop from Barrett-type epithelium via a sequence of progressively severe epithelial dysplasia, eventually leading to invasive carcinoma. Most of these tumors are well or moderately differentiated with columnar or cuboidal cells in tubular, glandular, or cribriform patterns (Fig 15) (38). Mucinous and signet-ring cell subtypes can also occur. Poorly differentiated tumors are diffusely infiltrative, often accompanied by a prominent desmoplastic reaction.

***Imaging Features.***—Adenocarcinoma of the esophagus may be indistinguishable from SCC at imaging on the basis of morphologic findings, but the vast majority of adenocarcinomas involve the lower third of the esophagus, and these tumors are much more likely to invade the stomach (61). Like SCCs, esophageal adenocarcinomas typically appear at barium examination as irregular, infiltrating lesions with irregular luminal narrowing, ulceration, and abrupt tumor margins (Fig 15) (41). Other findings at barium examination include a polypoid (Fig 16) or ulcerative lesion or a varicoid appearance with thickened, scalloped folds due to submucosal spread of tumor (61,63).

Teaching Point



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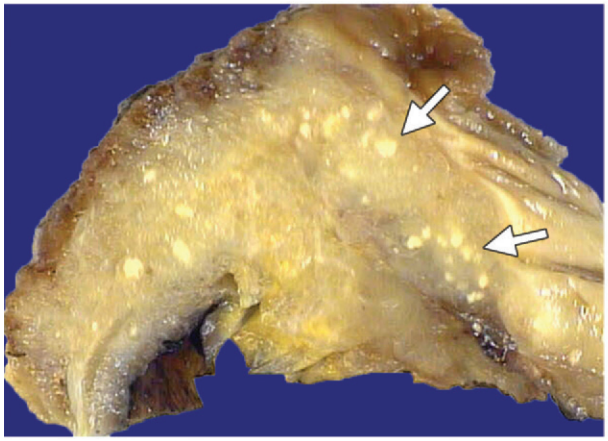

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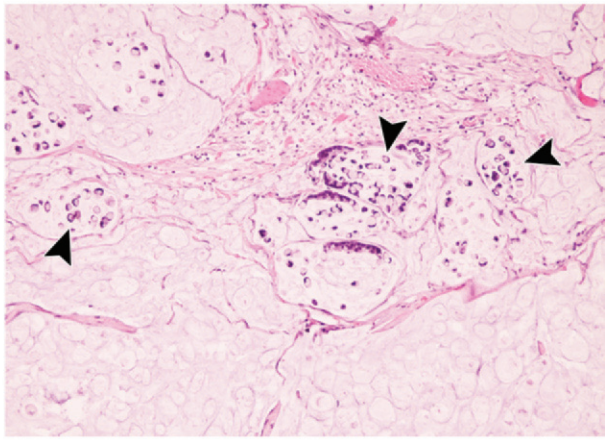


c.

**Figure 17.** Mucinous adenocarcinoma of the gastroesophageal junction in a 52-year-old man with dysphagia and anemia. **(a)** Axial contrast-enhanced CT image shows a low-attenuation mass with scattered punctate calcifications (arrows) involving the gastroesophageal junction and lesser curvature of the stomach. **(b)** Photograph of the sectioned gross specimen shows a yellow-tan shiny mass that contains calcifications (arrows). **(c)** Photomicrograph (original magnification, ×10; H-E stain) shows scattered clusters of signet-ring cells (arrowheads) within pools of mucin.

Early lesions can be quite subtle, sometimes resulting in slight flattening, irregularity, or stiffening of one wall of a preexisting peptic stricture (61). A reticular mucosal pattern of underlying Barrett esophagus can occasionally be seen adjacent to the tumor, but this finding is usually obliterated by more advanced cancers.

Cross-sectional imaging features of esophageal adenocarcinoma are similar to those of SCC, including asymmetric or circumferential wall thickening, uptake at FDG PET, and findings of regional and distant spread (Figs 15, 16). Mucinous adenocarcinomas may have slightly different imaging features, with low attenuation, calcification, and high T2 signal intensity secondary to extensive extracellular mucin (Fig 17) (55).

## Lymphoma

The esophagus is a rare site of extranodal lymphoma, accounting for less than 1% of all gastrointestinal lymphomas (64). Esophageal involvement usually results from direct extension of lymphoma to the esophagus from the stomach or adjacent lymph nodes in the mediastinum (65). Primary lymphoma of the esophagus is extremely rare; to our knowledge, fewer than 30 cases have been reported in the literature, primarily in men (66). Risk factors include human immunodeficiency virus (HIV) infection and chronic immunosuppression (7).

Dysphagia is a common presenting symptom of esophageal lymphoma, but many patients are asymptomatic. As a result, esophageal involvement is most often found at autopsy in the setting of widespread disease (67). Treatment includes some combination of chemotherapy, radiation therapy, and surgery. There is controversy about the use of surgery, as nonsurgical treatment may be equally effective (64).

***Pathologic Features.***—Lymphoma most commonly occurs in the distal esophagus. Gross appearances of esophageal lymphoma include a polypoid mass, an ulcerated lesion, submucosal infiltration, or multifocal nodules (Fig 18).

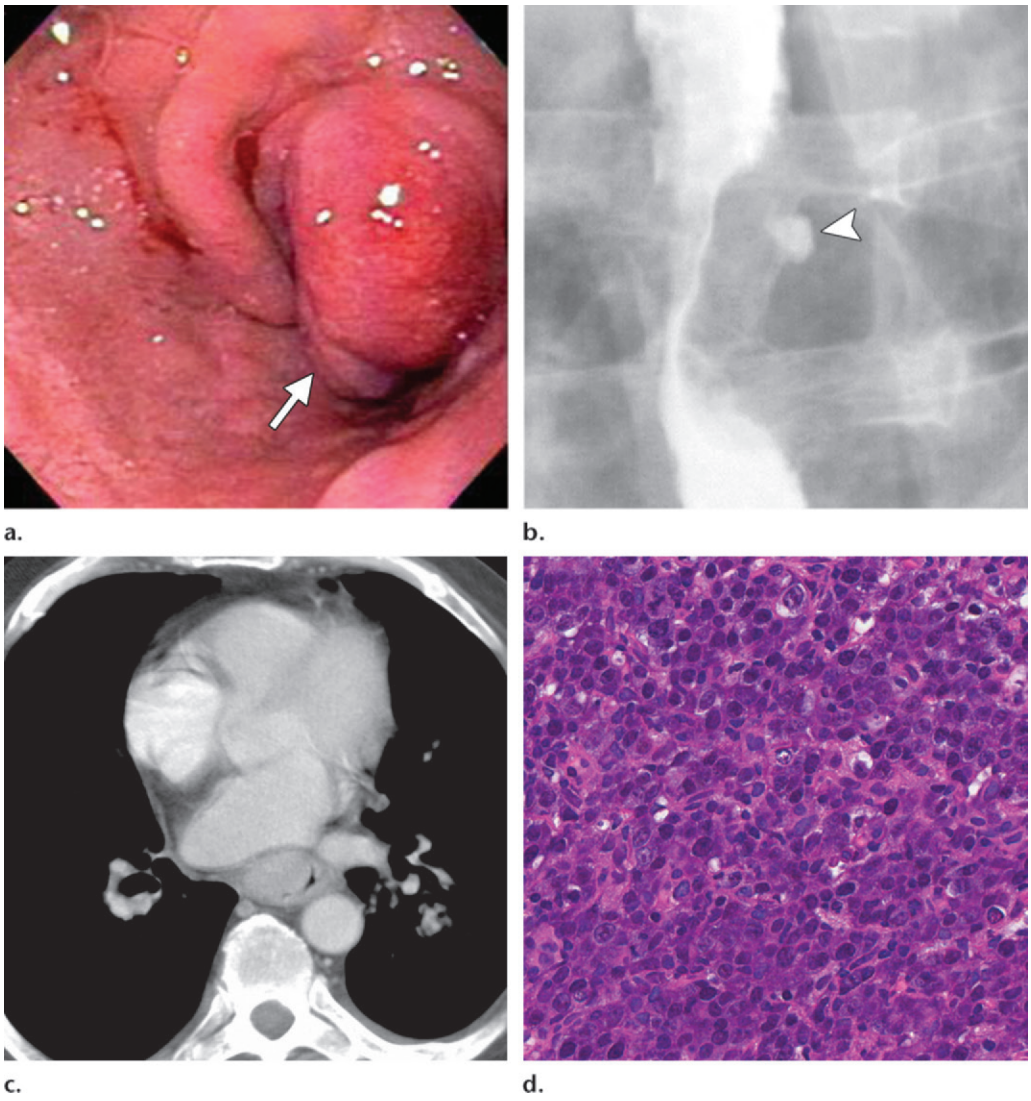



**Figure 18.** Primary esophageal diffuse large B-cell lymphoma in a 58-year-old man with HIV infection and a 3-week history of progressive odynophagia. **(a)** Photograph from upper endoscopy shows a submucosal mass (arrow). **(b)** Image from single-contrast esophagography shows a mass in the midesophagus containing an area of ulceration (arrowhead). **(c)** Axial contrast-enhanced CT image shows a homogeneous soft-tissue mass impinging on the esophageal lumen. **(d)** Photomicrograph (original magnification, ×40; H-E stain) shows numerous large, pleomorphic lymphoid cells with prominent nucleoli.

Non-Hodgkin lymphoma, specifically diffuse large B-cell lymphoma, accounts for the majority of esophageal lymphomas. Other reported types include Hodgkin disease, immunoblastic B-cell lymphoma, mucosa-associated lymphoid tissue (MALT), and T-cell lymphoma. MALT is not native to the esophagus but is found in 5% of patients with Barrett esophagus (64).

***Imaging Features.***—As expected from the varied gross appearances of esophageal lymphoma, diverse imaging manifestations have been reported. At barium esophagography, esophageal involvement most commonly appears as irregular narrowing of the distal esophagus due to direct spread of tumor from the adjacent proximal stomach (68). Esophageal lymphoma may also result in multiple submucosal nodules, polypoid or ulcerated lesions (Fig 18), enlarged folds, or rarely aneurysmal dilatation of the esophagus (65,67).

Findings at cross-sectional imaging are nonspecific. At CT, lymphoma can cause concentric or asymmetric thickening of the esophageal wall

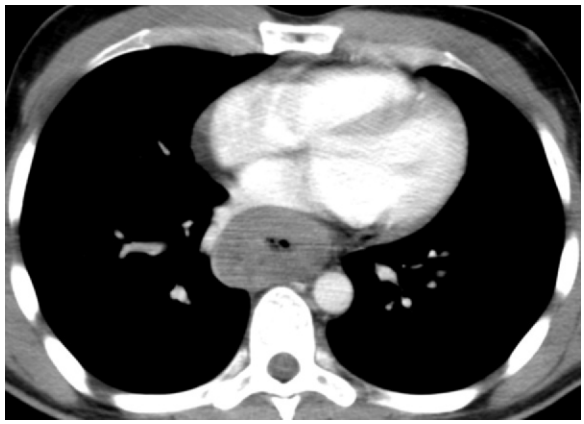
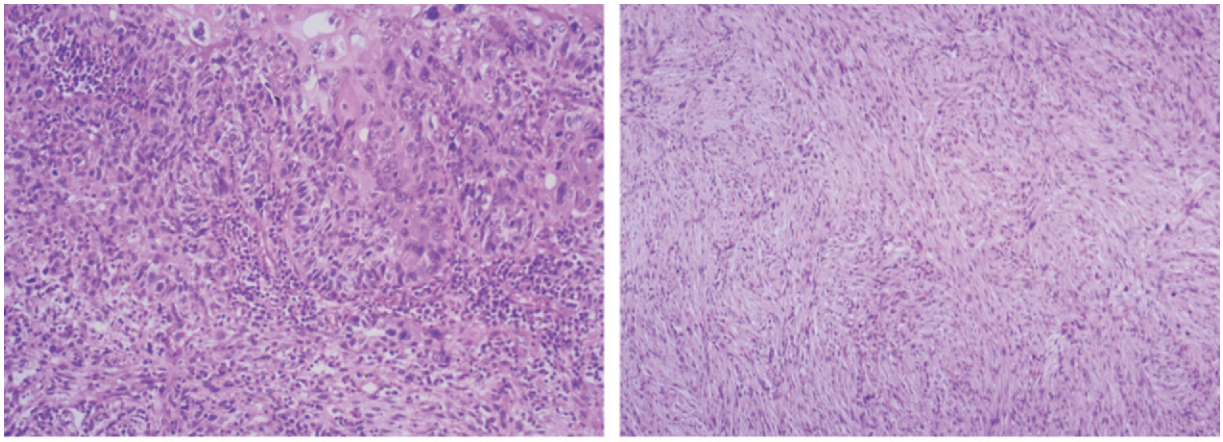


**Figure 19.** Primary esophageal diffuse large B-cell lymphoma in a 37-year-old man with HIV infection and a history of dysphagia and odynophagia. Axial contrast-enhanced CT image shows marked wall thickening of the esophagus. The fat plane with the adjacent aorta is intact.



a. b.

**Figure 20.** Spindle cell carcinoma in a 56-year-old man with a 4-week history of dysphagia. **(a)** Photomicrograph (original magnification, ×20; H-E stain) shows the squamous component with pleomorphic cells. **(b)** Photomicrograph (original magnification, ×10; H-E stain) shows the sarcomatous component with spindle-shaped cells.

with or without adjacent mediastinal lymphadenopathy (Fig 19). An intact fat plane between a large esophageal tumor and neighboring structures supports the diagnosis of esophageal lymphoma (66). At endoscopic US, this tumor most commonly manifests as transmural homogeneous hypoechoic thickening, although anechoic and hyperechoic masses have also been reported (66,69). The most common types of lymphoma to involve the esophagus typically demonstrate avid FDG uptake (70).

## Spindle Cell Carcinoma

Spindle cell carcinoma is a biphasic malignancy with squamous and sarcomatous components, described in the esophagus in 1904 by Hansemann (71). Because of debate surrounding its etiology, this rare tumor has variously been called carcinosarcoma, pseudosarcoma, polypoid carcinoma, sarcomatoid carcinoma, and SCC with spindle cell component. Spindle cell carcinoma is currently considered to be a variant of SCC, with a varying degree of sarcomatous metaplasia of the carcinomatous portion of the tumor.

Spindle cell carcinoma accounts for 0.5%–2.8% of all malignant esophageal tumors, occurring primarily in middle-aged and elderly men presenting with dysphagia and weight loss (72). Although this tumor is characterized predominantly by intraluminal growth rather than esophageal wall invasion, the prognosis is comparable to that of SCC (73,74).

***Pathologic Features.***—Spindle cell carcinomas usually appear grossly as bulky polypoid intraluminal masses. They are often pedunculated and

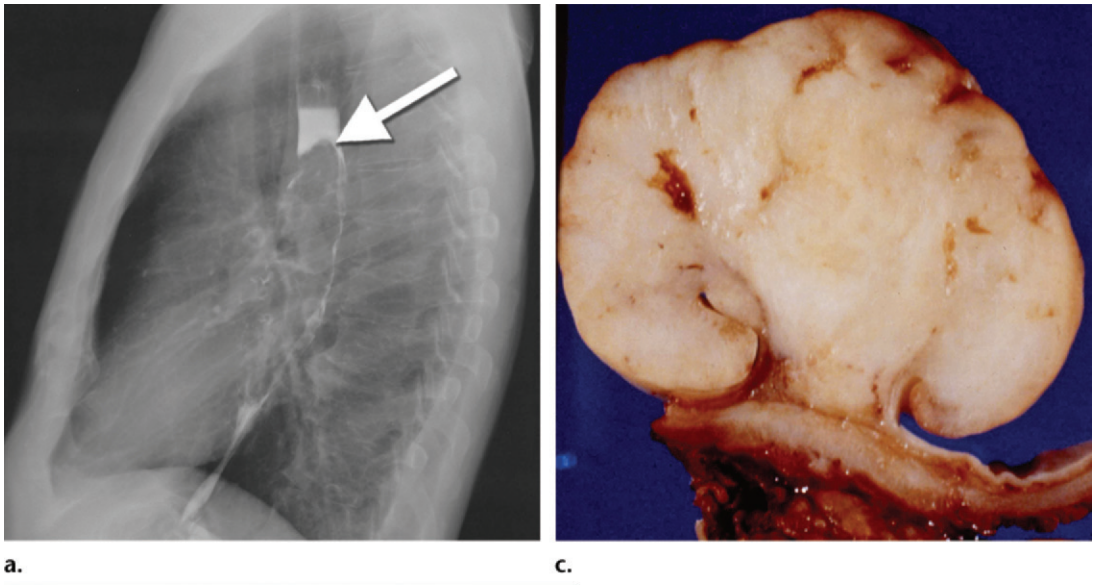



**Figure 21.** Spindle cell carcinoma in a 57-year-old man with weight loss and malaise. **(a)** Spot image from single-contrast esophagography shows a sausage-shaped filling defect expanding the lumen, with a domed appearance superiorly (arrow). **(b)** Axial contrast-enhanced CT image shows a homogeneous hypoattenuating intraluminal mass in the esophagus surrounded by oral contrast material and air. **(c)** Photograph of the sectioned gross specimen shows a lobulated mass attached by a pedicle to the esophageal wall.

have a scalloped, smooth, or ulcerated surface. Rarely, these tumors may have an infiltrative appearance that mimics that of typical SCC. More than 80% of spindle cell carcinomas arise in the middle or lower esophagus (72).

Spindle cell carcinoma contains both carcinomatous and sarcomatous components (Fig 20). The carcinomatous component may be invasive SCC, carcinoma in situ, or rarely adenocarcinoma, with cells that are positive for epithelial markers such as cytokeratin. The sarcomatous component consists of pleomorphic spindle-shaped cells in an edematous matrix and sometimes has areas of osseous, cartilaginous, or skeletal muscle differentiation (75). Sarcomatous tumor cells stain for the mesenchymal marker vimentin, but some may also react with epithelial markers as evidence of their origin. The sarcomatous or carcinomatous component, or both, can metastasize to local or distant structures.

***Imaging Features.***—At barium examination, spindle cell carcinoma is typically seen as a large polypoid intraluminal mass with a scalloped surface in the mid to distal esophagus (76,77). These tumors usually expand or dilate the esophagus without causing obstruction (65). A cupola, or domed appearance, is sometimes seen at the superior edge of the tumor (Fig 21). Less commonly, spindle cell carcinoma may cause irregular narrowing and ulceration indistinguishable from that of esophageal SCC or adenocarcinoma. CT may reveal either a large low-attenuation intraluminal mass without proximal dilatation (Fig 21) or localized wall thickening (76,78).

Primary malignant melanoma of the esophagus may appear as a polypoid intraluminal mass indistinguishable from spindle cell carcinoma, although it is less common (79). The differential diagnosis of large intraluminal esophageal masses also includes SCC and adenocarcinoma of the esophagus (which rarely may appear as bulky polypoid masses) as well as lymphoma and other rare sarcomas.

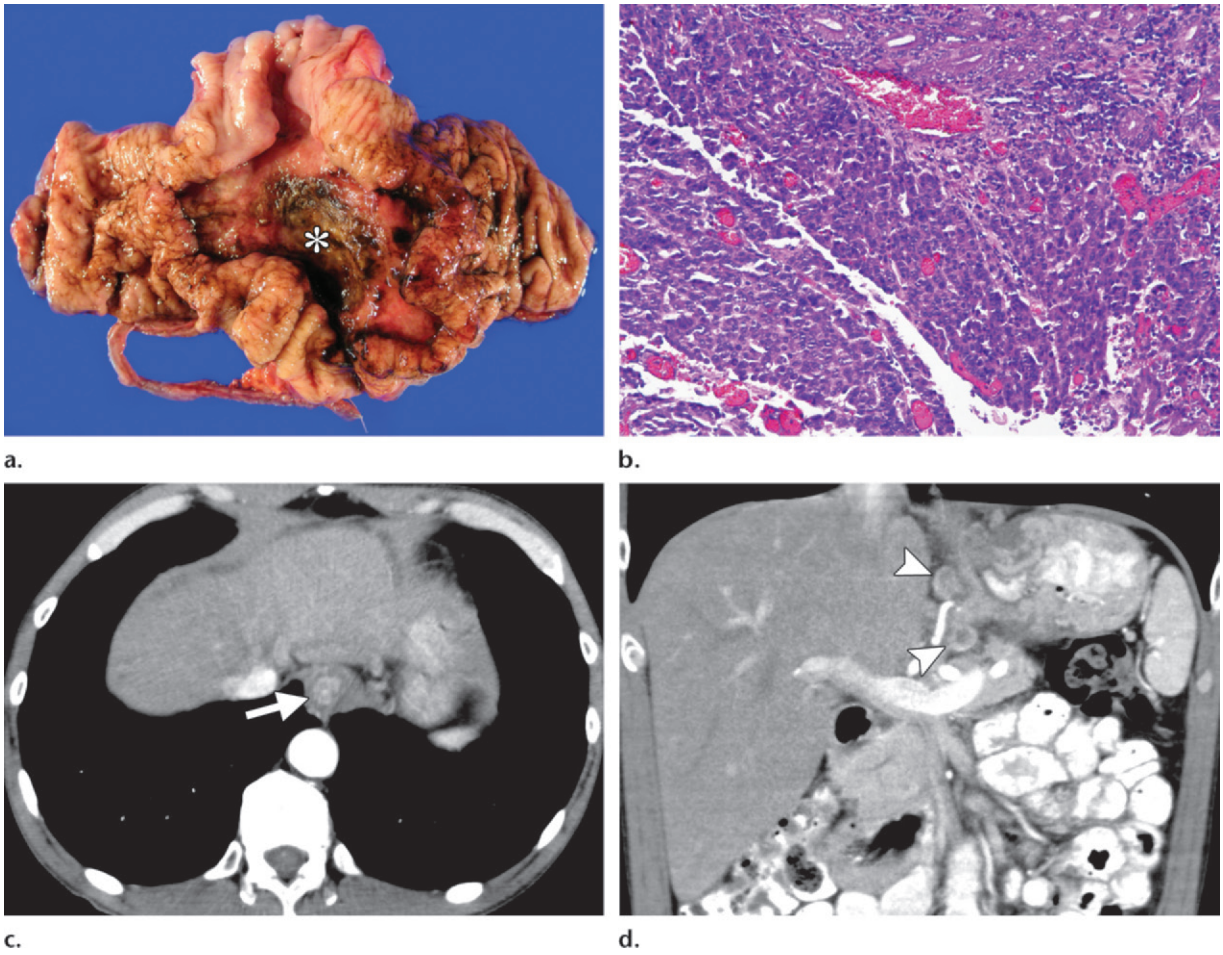



**Figure 22.** Neuroendocrine carcinoma in a 50-year-old man with one episode of dysphagia. **(a)** Photograph of the gross specimen shows an irregular ulcer (*) at the gastroesophageal junction. **(b)** Photomicrograph (original magnification, ×40; H-E stain) shows infiltrating sheets of basophilic cells with hyperchromatic nuclei and scant cytoplasm. **(c)** Axial contrast-enhanced CT image shows a hyperenhancing mass (arrow) in the distal esophagus. **(d)** Coronal contrast-enhanced CT image shows lymph node metastases (arrowheads) with peripheral hyperenhancement and central low attenuation from necrosis.

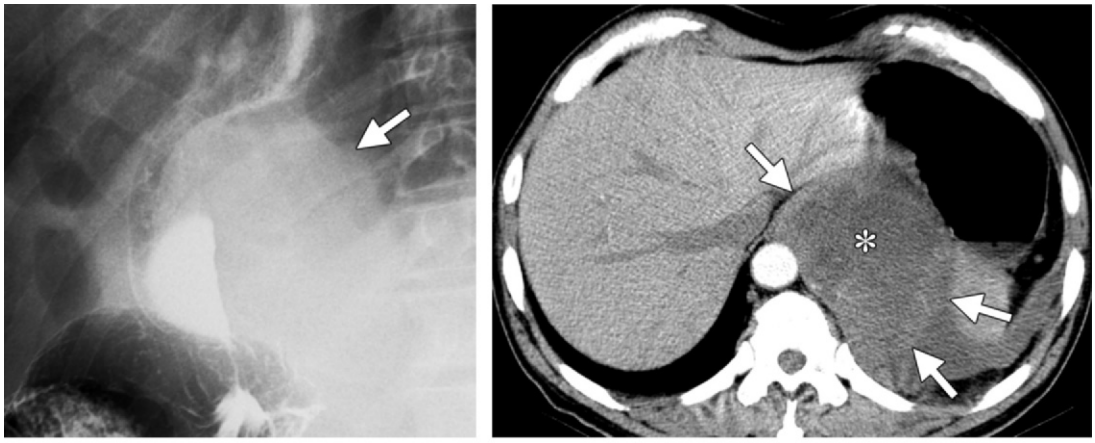
Fibrovascular polyps may also appear as polypoid intraluminal masses, but these tumors usually have an extremely smooth contour and arise from the cervical esophagus, whereas spindle cell carcinomas are much more lobulated and usually arise from the mid or distal esophagus. Fibrovascular polyps also contain varying amounts of fat at CT, enabling differentiation from spindle cell carcinoma.

## Neuroendocrine Neoplasms

According to the most recent World Health Organization update, neuroendocrine neoplasms are classified as well-differentiated neuroendocrine tumors, which are low- or intermediate-grade, or poorly differentiated neuroendocrine carcinomas, which are high-grade and include small cell and large cell subtypes (7). In the esophagus, neuroendocrine carcinomas are more common than well-differentiated tumors and represent about 1% of esophageal cancers (40).

Neuroendocrine carcinomas are aggressive neoplasms; at the time of diagnosis, more than 70% of patients have metastases to the lymph nodes, liver, bones, or adrenal glands, in decreasing order of frequency (80). The prognosis is dismal for patients with high-grade tumors, with a median survival of only about 14 months (81).

***Pathologic Features.***—The location of neuroendocrine neoplasms parallels the location of endocrine cells in the esophagus, so these tumors tend to involve the distal esophagus and gastroesophageal junction (81,82). Well-differentiated tumors may be polypoid lesions, often less than 4 cm in size and discovered as incidental findings in Barrett mucosa (83). Neuroendocrine carcinomas are usually larger than 4 cm in size and can be ulcerated (Fig 22), fungating, or polypoid masses (84).



a. b.

**Figure 23.** Esophageal GIST in a 65-year-old man with a several-month history of dysphagia and weight loss. **(a)** Spot image from double-contrast esophagography shows displacement of the distal esophagus by a mass with a prominent exophytic component (arrow). **(b)** Axial contrast-enhanced CT image shows a large distal esophageal mass (arrows) with central low attenuation secondary to necrosis (*).

Small cell carcinoma is the most common histologic subtype of neuroendocrine carcinoma and resembles its counterpart in the lung, with small round to oval cells in sheets or nests (Fig 22). The cells have scant cytoplasm, hyperchromatic nuclei, and frequent mitotic figures and stain for neuroendocrine markers such as synaptophysin and chromogranin A.

***Imaging Features.***—At barium examination, small cell neuroendocrine carcinoma of the esophagus often appears as a sessile mass with central ulceration in the midesophagus; at CT, it is characterized by marked esophageal wall thickening (84,85). Other appearances include a polypoid, ulcerated, or infiltrating lesion (77,85).

Because of their abundant blood supply, gastrointestinal neuroendocrine neoplasms and their metastases usually show moderate or obvious arterial phase enhancement (Fig 22) (86). Other gastrointestinal neoplasms that may appear hypervascular include GIST, hypervascular metastases, Kaposi sarcoma, paraganglioma, and solitary fibrous tumor (87).

## Other Malignant Esophageal Neoplasms

Sarcomas are uncommon in the esophagus; leiomyosarcoma is the most frequent. At esophagography, leiomyosarcomas appear as intramural lesions with large exophytic components and areas of calcification and tracking (88). At CT, they appear as heterogeneous lesions containing large exophytic components, with central areas of necrosis and extraluminal gas or contrast material tracking in the tumor (88).

More recently, it has been suggested that GISTs are more frequent, likely accounting for many tumors previously designated as leiomyosarcomas (15). GISTs typically arise in the muscularis propria of the lower third of the esophagus. As with GISTs in the remainder of the gastrointestinal tract, small tumors are often intramural while larger tumors have an exophytic growth pattern and contain areas of necrosis (15). CT may reveal an exophytic mass that is homogeneous or heterogeneous from areas of necrosis and calcification (Fig 23) (14). Immunohistochemical analysis is very helpful in pathologic diagnosis, since esophageal GISTs are positive for CD117 and often CD34.

The esophagus can be involved by metastatic disease, which is found at autopsy in 3% of patients with a primary malignancy (89). Most metastases to the esophagus result from direct extension from adjacent organs or mediastinal lymph nodes. Hematogenous spread to the esophagus results in submucosal lesions that may spread circumferentially, producing a short stricture without mucosal ulceration or, less frequently, a long stricture or focal submucosal mass (89).

## Conclusions

Esophageal neoplasms may demonstrate a wide spectrum of imaging appearances based on their underlying pathologic features. SCC and adenocarcinoma are the two most common esophageal tumors, usually appearing as irregular, sometimes ulcerated areas of narrowing, with adenocarcinoma far more likely to involve the gastric cardia and fundus. Esophageal adenocarcinoma is the most common esophageal neoplasm in western countries and usually affects white men,

in contrast to SCC, which has a higher rate in black men and is the most common esophageal neoplasm worldwide. Neuroendocrine carcinoma can have an imaging appearance similar to that of SCC and adenocarcinoma, but hypervascular metastases may be present.

Spindle cell carcinoma and fibrovascular polyps are intraluminal polypoid masses that can be distinguished by their morphologic appearance, their sites of origin in the mid to distal and cervical esophagus, respectively, and their composition, with fibrovascular polyps often containing fat. Leiomyomas and granular cell tumors are intramural masses without mucosal irregularity or ulceration, although leiomyomas are far more common. Lymphoma has a variety of appearances but is usually secondary to disease outside the esophagus. Although biopsy or excision is required for definitive diagnosis, understanding the imaging appearances and pathologic bases of esophageal neoplasms is essential for their detection, differential diagnosis, staging, and treatment planning.

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## References

1. Ferlay J, Shin HR, Bray F, Forman D, Mathers C, Parkin DM. Estimates of worldwide burden of cancer in 2008: GLOBOCAN 2008. Int J Cancer 2010; 127(12):2893–2917.
2. Levine MS. Benign tumors of the esophagus. In: Gore RM, Levine MS, eds. Textbook of gastrointestinal radiology. 3rd ed. Philadelphia, Pa: Saunders, 2008; 401–416.
3. Rice TW. Benign esophageal tumors: esophagoscopy and endoscopic esophageal ultrasound. Semin Thorac Cardiovasc Surg 2003;15(1):20–26.
4. Seremetis MG, Lyons WS, deGuzman VC, Peabody JW Jr. Leiomyomata of the esophagus: an analysis of 838 cases. Cancer 1976;38(5):2166–2177.
5. Mutrie CJ, Donahue DM, Wain JC, et al. Esophageal leiomyoma: a 40-year experience. Ann Thorac Surg 2005;79(4):1122–1125.
6. Bourque MD, Spigland N, Bensoussan AL, et al. Esophageal leiomyoma in children: two case reports and review of the literature. J Pediatr Surg 1989;24 (10):1103–1107.
7. Montgomery E, Field JK, Boffetta P, et al. Tumours of the oesophagus. In: Bosman FT, Carneiro F, Hruban RH, Theise ND, eds. WHO classification of tumours of the digestive system. 4th ed. Lyon, France: IARC, 2010; 15–37.
8. Yang PS, Lee KS, Lee SJ, et al. Esophageal leiomyoma: radiologic findings in 12 patients. Korean J Radiol 2001;2(3):132–137.
9. Ghahremani GG, Meyers MA, Port RB. Calcified primary tumors of the gastrointestinal tract. Gastrointest Radiol 1978;2(4):331–339.
10. Levine MS. Benign tumors of the esophagus: radiologic evaluation. Semin Thorac Cardiovasc Surg 2003;15(1):9–19.
11. Xu GQ, Qian JJ, Chen MH, Ren GP, Chen HT. Endoscopic ultrasonography for the diagnosis and selecting treatment of esophageal leiomyoma. J Gastroenterol Hepatol 2012;27(3):521–525.
12. Depypere L, Coosemans W, Nafteux P. Fluorine-18-fluorodeoxyglucose uptake in a benign oesophageal leiomyoma: a potential pitfall in diagnosis. Interact Cardiovasc Thorac Surg 2012;14(2):234–236.
13. Rubesin S, Herlinger H, Sigal H. Granular cell tumors of the esophagus. Gastrointest Radiol 1985;10 (1):11–15.
14. Iannicelli E, Sapori A, Panzuto F, Pilozzi E, Delle Fave G, David V. Oesophageal GIST: MDCT findings of two cases and review of the literature. J Gastrointest Cancer 2012;43(3):481–485.
15. Miettinen M, Sarlomo-Rikala M, Sobin LH, Lasota J. Esophageal stromal tumors: a clinicopathologic, immunohistochemical, and molecular genetic study of 17 cases and comparison with esophageal leiomyomas and leiomyosarcomas. Am J Surg Pathol 2000;24(2):211–222.
16. Abraham SC, Krasinskas AM, Hofstetter WL, Swisher SG, Wu T-T. "Seedling" mesenchymal tumors (gastrointestinal stromal tumors and leiomyomas) are common incidental tumors of the esophagogastric junction. Am J Surg Pathol 2007;31(11): 1629–1635.
17. Levine MS, Buck JL, Pantongrag-Brown L, Buetow PC, Lowry MA, Sobin LH. Esophageal leiomyomatosis. Radiology 1996;199(2):533–536.
18. Kilian AK, Ringle T, Waag KL, Düber C, Neff KW. Pre- and postoperative MRI of esophageal and gastric leiomyomatosis in a pediatric patient. AJR Am J Roentgenol 2005;184(3 suppl):S129–S131.
19. Sargent RL, Hood IC. Asphyxiation caused by giant fibrovascular polyp of the esophagus. Arch Pathol Lab Med 2006;130(5):725–727.
20. Drenth J, Wobbes T, Bonenkamp JJ, Nagengast FM. Recurrent esophageal fibrovascular polyps: case history and review of the literature. Dig Dis Sci 2002; 47(11):2598–2604.
21. Lee SY, Chan WH, Sivanandan R, Lim DT, Wong WK. Recurrent giant fibrovascular polyp of the esophagus. World J Gastroenterol 2009;15(29): 3697–3700.
22. Choong CK, Meyers BF. Benign esophageal tumors: introduction, incidence, classification, and clinical features. Semin Thorac Cardiovasc Surg 2003;15(1):3–8.

23. Levine MS, Buck JL, Pantongrag-Brown L, Buetow PC, Hallman JR, Sobin LH. Fibrovascular polyps of the esophagus: clinical, radiographic, and pathologic findings in 16 patients. AJR Am J Roentgenol 1996;166(4):781–787.
24. Kim TS, Song SY, Han J, Shim YM, Jeong HS. Giant fibrovascular polyp of the esophagus: CT findings. Abdom Imaging 2005;30(6):653–655.
25. Stoane JM, Torrisi JM, Haller JO, David M. Fibrovascular polyps of the esophagus: MRI findings. J Comput Assist Tomogr 1995;19(1):157–159.
26. Lawrence SP, Larsen BR, Stacy CC, McNally PR. Echoendosonographic and histologic correlation of a fibrovascular polyp of the esophagus. Gastrointest Endosc 1994;40(1):81–84.
27. Vagli P, Solito B, Neri E, et al. Giant fibrovascular polyp of the esophagus: imaging techniques for proper treatment planning—report of two cases. Abdom Imaging 2012;37(4):512–518.
28. Abrikossoff AL. Über Myome. Virchows Arch 1926; 260(1):215–233.
29. Johnston J, Helwig EB. Granular cell tumors of the gastrointestinal tract and perianal region: a study of 74 cases. Dig Dis Sci 1981;26(9):807–816.
30. Narra SL, Tombazzi C, Datta V, Ismail MK. Granular cell tumor of the esophagus: report of five cases and review of the literature. Am J Med Sci 2008;335 (5):338–341.
31. Goldblum JR, Rice TW, Zuccaro G, Richter JE. Granular cell tumors of the esophagus: a clinical and pathologic study of 13 cases. Ann Thorac Surg 1996;62(3):860–865.
32. David O, Jakate S. Multifocal granular cell tumor of the esophagus and proximal stomach with infiltrative pattern: a case report and review of the literature. Arch Pathol Lab Med 1999;123(10):967–973.
33. Xu GQ, Chen HT, Xu CF, Teng XD. Esophageal granular cell tumors: report of 9 cases and a literature review. World J Gastroenterol 2012;18(47): 7118–7121.
34. Boncoeur-Martel MP, Loevner LA, Yousem DM, Elder DE, Weinstein GS. Granular cell myoblastoma of the cervical esophagus: MR findings. AJNR Am J Neuroradiol 1996;17(9):1794–1797.
35. Kudawara I, Ueda T, Yoshikawa H. Granular cell tumor of the subcutis: CT and MRI findings—a report of three cases. Skeletal Radiol 1999;28(2): 96–99.
36. Kawaura Y. Squamous cell papilloma of the esophagus: report of 17 cases and review of the literature. Esophagus 2005;2(3):161–164.
37. Edge SB, Byrd DR, Compton CC, Fritz AG, Greene FL, Trotti A. Esophagus and esophagogastric junction. In: Edge SB, Byrd DR, Compton CC, Fritz AG, Greene FL, Trotti A, eds. AJCC cancer staging manual. 7th ed. New York, NY: Springer, 2009; 103–115.
38. Glickman JN. Section II: pathology and pathologic staging of esophageal cancer. Semin Thorac Cardiovasc Surg 2003;15(2):167–179.
39. Cook MB, Chow WH, Devesa SS. Oesophageal cancer incidence in the United States by race, sex, and histologic type, 1977-2005. Br J Cancer 2009; 101(5):855–859.
40. Trivers KF, Sabatino SA, Stewart SL. Trends in esophageal cancer incidence by histology, United States, 1998-2003. Int J Cancer 2008;123(6): 1422–1428.
41. Levine MS, Halvorsen RA. Carcinoma of the esophagus. In: Gore RM, Levine MS, eds. Textbook of gastrointestinal radiology. 3rd ed. Philadelphia, Pa: Saunders, 2008; 417–446.
42. Lee SS, Ha HK, Byun JH, et al. Superficial esophageal cancer: esophagographic findings correlated with histopathologic findings. Radiology 2005;236 (2):535–544.
43. Iyer RB, Silverman PM, Tamm EP, Dunnington JS, DuBrow RA. Diagnosis, staging, and follow-up of esophageal cancer. AJR Am J Roentgenol 2003;181 (3):785–793.
44. Japan Esophageal Society. Japanese Classification of Esophageal Cancer, tenth edition: part I. Esophagus 2009;6(1):1–25.
45. Lindell MM Jr, Hill CA, Libshitz HI. Esophageal cancer: radiographic chest findings and their prognostic significance. AJR Am J Roentgenol 1979;133 (3):461–465.
46. Levine MS, Chu P, Furth EE, Rubesin SE, Laufer I, Herlinger H. Carcinoma of the esophagus and esophagogastric junction: sensitivity of radiographic diagnosis. AJR Am J Roentgenol 1997;168(6): 1423–1426.
47. Gupta S, Levine MS, Rubesin SE, Katzka DA, Laufer I. Usefulness of barium studies for differentiating benign and malignant strictures of the esophagus. AJR Am J Roentgenol 2003;180(3):737–744.
48. Reinig JW, Stanley JH, Schabel SI. CT evaluation of thickened esophageal walls. AJR Am J Roentgenol 1983;140(5):931–934.
49. Umeoka S, Koyama T, Togashi K, et al. Esophageal cancer: evaluation with triple-phase dynamic CT—initial experience. Radiology 2006;239(3):777–783.
50. Picus D, Balfe DM, Koehler RE, Roper CL, Owen JW. Computed tomography in the staging of esophageal carcinoma. Radiology 1983;146(2):433–438.
51. Botet JF, Lightdale C. Endoscopic sonography of the upper gastrointestinal tract. AJR Am J Roentgenol 1991;156(1):63–68.
52. Lightdale CJ, Kulkarni KG. Role of endoscopic ultrasonography in the staging and follow-up of esophageal cancer. J Clin Oncol 2005;23(20): 4483–4489.
53. Kim TJ, Kim HY, Lee KW, Kim MS. Multimodality assessment of esophageal cancer: preoperative staging and monitoring of response to therapy. RadioGraphics 2009;29(2):403–421.
54. Vilgrain V, Mompoint D, Palazzo L, et al. Staging of esophageal carcinoma: comparison of results with endoscopic sonography and CT. AJR Am J Roentgenol 1990;155(2):277–281.
55. Riddell AM, Hillier J, Brown G, et al. Potential of surface-coil MRI for staging of esophageal cancer. AJR Am J Roentgenol 2006;187(5):1280–1287.
56. Takashima S, Takeuchi N, Shiozaki H, et al. Carcinoma of the esophagus: CT vs MR imaging in determining resectability. AJR Am J Roentgenol 1991; 156(2):297–302.

57. Block MI, Patterson GA, Sundaresan RS, et al. Improvement in staging of esophageal cancer with the addition of positron emission tomography. Ann Thorac Surg 1997;64(3):770–776; discussion 776–777.
58. Bruzzi JF, Munden RF, Truong MT, et al. PET/CT of esophageal cancer: its role in clinical management. RadioGraphics 2007;27(6):1635–1652.
59. Hvid-Jensen F, Pedersen L, Drewes AM, Sørensen HT, Funch-Jensen P. Incidence of adenocarcinoma among patients with Barrett's esophagus. N Engl J Med 2011;365(15):1375–1383.
60. Siewert JR, Stein HJ, Feith M, Bruecher BLDM, Bartels H, Fink U. Histologic tumor type is an independent prognostic parameter in esophageal cancer: lessons from more than 1,000 consecutive resections at a single center in the western world. Ann Surg 2001;234(3):360–367; discussion 368–369.
61. Levine MS, Caroline D, Thompson JJ, Kressel HY, Laufer I, Herlinger H. Adenocarcinoma of the esophagus: relationship to Barrett mucosa. Radiology 1984;150(2):305–309.
62. Paraf F, Fléjou JF, Pignon JP, Fékété F, Potet F. Surgical pathology of adenocarcinoma arising in Barrett's esophagus: analysis of 67 cases. Am J Surg Pathol 1995;19(2):183–191.
63. Agha FP. Barrett carcinoma of the esophagus: clinical and radiographic analysis of 34 cases. AJR Am J Roentgenol 1985;145(1):41–46.
64. Chadha KS, Hernandez-Ilizaliturri FJ, Javle M. Primary esophageal lymphoma: case series and review of the literature. Dig Dis Sci 2006;51(1):77–83.
65. Levine MS. Other malignant tumors of the esophagus. In: Gore RM, Levine MS, eds. Textbook of gastrointestinal radiology. 3rd ed. Philadelphia, Pa: Saunders, 2008; 447–464.
66. Ghimire P, Wu GY, Zhu L. Primary esophageal lymphoma in immunocompetent patients: two case reports and literature review. World J Radiol 2010; 2(8):334–338.
67. Levine MS, Sunshine AG, Reynolds JC, Saul SH. Diffuse nodularity in esophageal lymphoma. AJR Am J Roentgenol 1985;145(6):1218–1220.
68. Carnovale RL, Goldstein HM, Zornoza J, Dodd GD. Radiologic manifestations of esophageal lymphoma. AJR Am J Roentgenol 1977;128(5):751–754.
69. Kalogeropoulos IV, Chalazonitis AN, Tsolaki S, et al. A case of primary isolated non-Hodgkin's lymphoma of the esophagus in an immunocompetent patient. World J Gastroenterol 2009;15(15): 1901–1903.
70. Paes FM, Kalkanis DG, Sideras PA, Serafini AN. FDG PET/CT of extranodal involvement in non-Hodgkin lymphoma and Hodgkin disease. RadioGraphics 2010;30(1):269–291.
71. Hansemann V. Das gleichzeitige Vorkommen verschiedenartiger Geschwülste bei derselben Person. Z Krebsforsch 1904;1(1-5):183–198.
72. Iascone C, Barreca M. Carcinosarcoma and pseudosarcoma of the esophagus: two names, one disease—comprehensive review of the literature. World J Surg 1999;23(2):153–157.
73. Iyomasa S, Kato H, Tachimori Y, Watanabe H, Yamaguchi H, Itabashi M. Carcinosarcoma of the esophagus: a twenty-case study. Jpn J Clin Oncol 1990;20 (1):99–106.
74. Sano A, Sakurai S, Kato H, et al. Clinicopathological and immunohistochemical characteristics of esophageal carcinosarcoma. Anticancer Res 2009;29 (8):3375–3380.
75. Raza MA, Mazzara PF. Sarcomatoid carcinoma of esophagus. Arch Pathol Lab Med 2011;135(7): 945–948.
76. Agha FP, Keren DF. Spindle-cell squamous carcinoma of the esophagus: a tumor with biphasic morphology. AJR Am J Roentgenol 1985;145(3): 541–545.
77. Olmsted WW, Lichtenstein JE, Hyams VJ. Polypoid epithelial malignancies of the esophagus. AJR Am J Roentgenol 1983;140(5):921–925.
78. Sadej P, Feld RI, Toll AD, Palazzo JP. AIRP best cases in radiologic-pathologic correlation: spindle cell carcinoma of the esophagus. RadioGraphics 2011;31(7):2035–2039.
79. Yoo CC, Levine MS, McLarney JK, Lowry MA. Primary malignant melanoma of the esophagus: radiographic findings in seven patients. Radiology 1998;209(2):455–459.
80. Beyer KL, Marshall JB, Diaz-Arias AA, Loy TS. Primary small-cell carcinoma of the esophagus: report of 11 cases and review of the literature. J Clin Gastroenterol 1991;13(2):135–141.
81. Maru DM, Khurana H, Rashid A, et al. Retrospective study of clinicopathologic features and prognosis of high-grade neuroendocrine carcinoma of the esophagus. Am J Surg Pathol 2008;32(9): 1404–1411.
82. Lindberg GM, Molberg KH, Vuitch MF, Albores-Saavedra J. Atypical carcinoid of the esophagus: a case report and review of the literature. Cancer 1997;79(8):1476–1481.
83. Hoang MP, Hobbs CM, Sobin LH, Albores-Saavedra J. Carcinoid tumor of the esophagus: a clinicopathologic study of four cases. Am J Surg Pathol 2002;26(4):517–522.
84. Mulder LD, Gardiner GA, Weeks DA. Primary small cell carcinoma of the esophagus: case presentation and review of the literature. Gastrointest Radiol 1991;16(1):5–10.
85. Levine MS, Pantongrag-Brown L, Buck JL, Buetow PC, Lowry MA, Sobin LH. Small-cell carcinoma of the esophagus: radiographic findings. Radiology 1996;199(3):703–705.
86. Wang D, Zhang GB, Yan L, Wei XE, Zhang YZ, Li WB. CT and enhanced CT in diagnosis of gastrointestinal neuroendocrine carcinomas. Abdom Imaging 2012;37(5):738–745.
87. Lee NK, Kim S, Kim GH, et al. Hypervascular subepithelial gastrointestinal masses: CT-pathologic correlation. RadioGraphics 2010;30(7):1915–1934.
88. Levine MS, Buck JL, Pantongrag-Brown L, Buetow PC, Hallman JR, Sobin LH. Leiomyosarcoma of the esophagus: radiographic findings in 10 patients. AJR Am J Roentgenol 1996;167(1):27–32.
89. Agha FP. Secondary neoplasms of the esophagus. Gastrointest Radiol 1987;12(3):187–193.

RadioGraphics

# From the Radiologic Pathology Archives
# Esophageal Neoplasms: Radiologic-Pathologic Correlation

*Rachel B. Lewis, MD • Anupamjit K. Mehrotra, MD • Pablo Rodriguez, MD • Marc S. Levine, MD*

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**Page 1086**
At barium examination, leiomyomas exhibit the typical findings of an intramural mass, appearing as smooth-surfaced crescent-shaped filling defects that form right angles or slightly obtuse angles with the adjacent esophageal wall.

**Page 1090**
The cross-sectional appearance of fibrovascular polyps depends on the proportions of fat and fibrous tissue in these lesions. A heterogeneous appearance may be seen, with areas of fat attenuation, hyperechogenicity, or high T1 signal from adipose tissue mixed with areas of soft-tissue attenuation, hypoechogenicity, or low T1 signal from fibrovascular tissue, or one component may predominate.

**Page 1092**
General imaging findings of malignancy include a stricture or mass with mucosal irregularity or ulceration at barium esophagography and evidence of tumor spread with infiltration of the periesophageal fat, lymphadenopathy, or distant metastases at cross-sectional imaging.

**Page 1095**
Features of mediastinal invasion include loss of intervening fat planes and displacement or indentation of the trachea or other mediastinal structures. Contact of the tumor with 90° or more of the aortic circumference is worrisome for aortic invasion.

**Page 1099**
Adenocarcinoma of the esophagus may be indistinguishable from SCC at imaging on the basis of morphologic findings, but the vast majority of adenocarcinomas involve the lower third of the esophagus, and these tumors are much more likely to invade the stomach.