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Diseases of the esophagus: a pattern approach

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Abstract

The esophagus may be involved by a variety of morphologic abnormalities, including nodules and plaques, ulceration, distal esophageal strictures and rings, upper or midesophageal strictures, and diffuse narrowing (also known as a small-caliber esophagus). The use of a pattern approach for evaluating esophageal disease on barium studies facilitates diagnosis of a host of pathologic conditions associated with these morphologic abnormalities. This article therefore presents an approach for diagnosing esophageal disease on barium studies that emphasizes the radiographic and clinical features used to differentiate the underlying causes of disease and the diagnostic pitfalls associated with performing and interpreting these studies.

Key words: Barium swallow—Esophagram—Esophagography—Esophageal disease—Pattern approach

Barium esophagography is the primary radiologic technique for diagnosing esophageal disease. We believe that the best way to interpret these examinations is not via a disease-oriented approach, but rather via a pattern approach that combines the radiographic findings with the clinical history and presentation. This article therefore presents a pattern approach for the diagnosis of esophageal disease on barium studies, emphasizing the radiographic and clinical features used to differentiate abnormalities and the diagnostic pitfalls associated with performing and interpreting these studies.

Technique of examination

Barium esophagography usually is performed as a biphasic study that includes both upright double-contrast views and prone single-contrast views of the esophagus [1, 2]. After ingesting an effervescence agent, the patient swallows high-density barium in the upright, left posterior oblique position for double-contrast views of the esophagus. It is important for the patient to swallow the barium continuously (though not necessarily rapidly), as repetitive swallowing inhibits esophageal peristalsis, so double-contrast views can be obtained while the esophagus is adequately distended. The patient is then placed in a right-side-down position for a double-contrast spot image of the gastric cardia, which is recognized by three or four stellate folds radiating to a central point at the gastroesophageal junction, also known as the cardiac rosette [1, 2]. The patient is next placed in a prone, right anterior oblique position and takes single swallows of thin barium to evaluate esophageal motility and then continuously swallows thin barium to optimally distend the esophagus and rule out rings, strictures, or other causes of narrowing. The single- and double-contrast phases of this biphasic examination are complementary, as double-contrast views enable detection of mucosal abnormalities not visible on single-contrast views, whereas single-contrast views enable detection of areas of narrowing not visible on double-contrast views.

Disease patterns: nodules and plaques

Radiographic findings

Reflux esophagitis

Fine nodularity or granularity of the mucosa in the distal esophagus is by far the most common sign of reflux esophagitis on double-contrast esophagrams [3]. This finding is characterized on double-contrast images by tiny, poorly defined nodules secondary to mucosal edema and inflammation, producing a *granular* appearance that extends proximally from the gastroesophageal junction as a continuous area of disease (Figs. 1, 2) [3, 4]. While these patients may have gastroesophageal reflux (GER) at fluoroscopy, GER often results from transient lower esophageal sphincter relaxations rather than from

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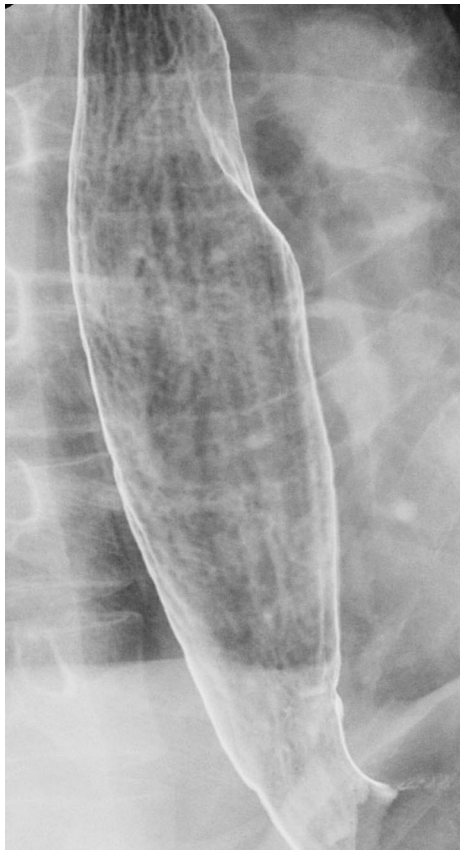

Fig. 1. Reflux esophagitis with granular mucosa. Upright, left posterior oblique spot image from double-contrast esophagram shows extensive granularity in lower third of thoracic esophagus secondary to mucosal edema and inflammation. This finding is characteristic of reflux esophagitis.

a sustained decrease in sphincter pressure [4]. As a result, some patients with reflux esophagitis have episodic GER that is not detected at fluoroscopy.

Candida esophagitis

Candida esophagitis is characterized by multiple discrete plaque-like lesions that have a linear or irregular configuration and are separated by normal intervening mucosa (Fig. 3) [5–7]. The plaques tend to be located in the upper and midesophagus but can have a localized or diffuse distribution. These findings enable differentiation of *Candida* esophagitis from the continuous granularity of reflux esophagitis [5–7]. Double-contrast esophagrams have a sensitivity of approximately 90% in detecting *Candida* esophagitis, primarily because of the ability to show these mucosal plaques [5, 6].

Patients with AIDS occasionally may develop a more fulminant form of *Candida* esophagitis characterized by a grossly irregular or *shaggy* esophagus secondary to innumerable plaques and pseudomembranes, with trapping of barium between these lesions (Fig. 4) [8]. Since this florid form of *Candida* esophagitis rarely is encountered in other immunocompromised patients, the radiologist performing the study may be the first to suggest that the patient has AIDS. With improved antiviral therapy for human immunodeficiency virus (HIV), HIV-positive patients are far less likely to develop AIDS, so the shaggy esophagus of candidiasis has become an infrequent finding in modern radiology practice.

Glycogenic acanthosis

Glycogenic acanthosis is a common degenerative condition characterized by accumulation of cytoplasmic glycogen in the squamous epithelial cells lining the esophagus [9]. This condition is not premalignant and causes no symptoms, so it is important only because it sometimes can be mistaken for other pathologic entities. Glycogenic acanthosis is manifested on double-contrast esophagrams by discrete, widely scattered, round or ovoid nodules and plaques in the mid or, less commonly, distal esophagus (Fig. 5) [9]. While the nodules of glycogenic acanthosis usually are rounder and more sporadic than the plaques of *Candida* esophagitis, it can be difficult to differentiate these conditions solely on the basis of the radiographic findings.

Superficial spreading carcinoma

Superficial spreading carcinoma is an unusual form of esophageal cancer in which tumor spreads via the mucosa without protruding substantially into the lumen (Fig. 6) [10, 11]. Early endoscopy and biopsy are required for a definitive diagnosis, so these patients can be treated before they develop more advanced disease. Superficial spreading carcinomas are manifested on double-contrast studies by a focal cluster of nodules or plaques that have poorly defined borders and merge with one another, producing a confluent area of disease [10, 11]. In contrast, the plaques and nodules of *Candida* esophagitis and glycogenic acanthosis have more discrete borders and are separated by normal intervening mucosa, enabling differentiation of these conditions from superficial spreading carcinoma in most cases.

Barrett's esophagus

Barrett's esophagus occasionally is manifested on double-contrast studies by a delicate reticular pattern characterized by multiple thin, parallel or intersecting barium-filled grooves on the mucosa (Fig. 7) [4, 12]. This distinctive reticular pattern often is found to extend distally a variable distance from a midesophageal stricture [12] but can also be seen without an associated stricture. In the presence of a hiatal hernia and GER, a reticular mucosal pattern is thought to be highly suggestive of Barrett's esophagus. Nevertheless, this finding is encountered in only 5–10% of all patients with Barrett's esophagus [4].

Fig. 2. Reflux esophagitis with flow artifact. Upright, left posterior oblique spot image from double-contrast esophagram shows a smooth, featureless mucosa. However, there is a continuous sheen in the distal esophagus secondary to excess high-density barium coating mucosa. Additional spot image after barium has thinned out shows characteristic granularity of reflux esophagitis previously obscured by flow artifact.

Clinical aspects

Patients with reflux esophagitis classically present with heartburn and/or regurgitation, but they can also experience dysphagia, epigastric pain, dyspepsia, upper gastrointestinal bleeding, pharyngitis, laryngitis, hoarseness, asthma, or recurrent episodes of aspiration pneumonia [4]. In contrast, *Candida* esophagitis typically occurs in immunocompromised patients with dysphagia or, even more commonly, odynophagia (painful swallowing) [7], whereas glycogenic acanthosis occurs in older patients (over 60 years of age) who are not immunocompromised and have no esophageal symptoms [9]. These conditions therefore usually can be differentiated on the basis of the clinical history and presentation.

Patients with superficial spreading carcinomas generally are asymptomatic; dysphagia develops only after tumor compromises the esophageal lumen by 50–75% [11]. Endoscopy and biopsy therefore are needed to rule out carcinoma, even in the absence of symptoms, when suspicious findings are encountered on barium studies. In contrast, patients with a reticular pattern secondary to Barrett's esophagus may present with reflux symptoms or dysphagia because of their underlying reflux disease.

Diagnostic pitfalls

A common pitfall in the diagnosis of reflux esophagitis on double-contrast esophagrams is *flow artifact*, in which excess high-density barium coating the mucosa creates a white sheen that obscures underlying granularity, resulting in false-negative studies (see Fig. 2a) [2, 13]. This artifact can be avoided by obtaining images after the barium pool has thinned out enough to visualize a granular mucosa (see Fig. 2b).

In contrast, the most common pitfall in the diagnosis of *Candida* esophagitis on double-contrast esophagrams is undissolved effervescent agent mimicking the plaques of candidiasis (Fig. 8a) [7]. In such cases, additional

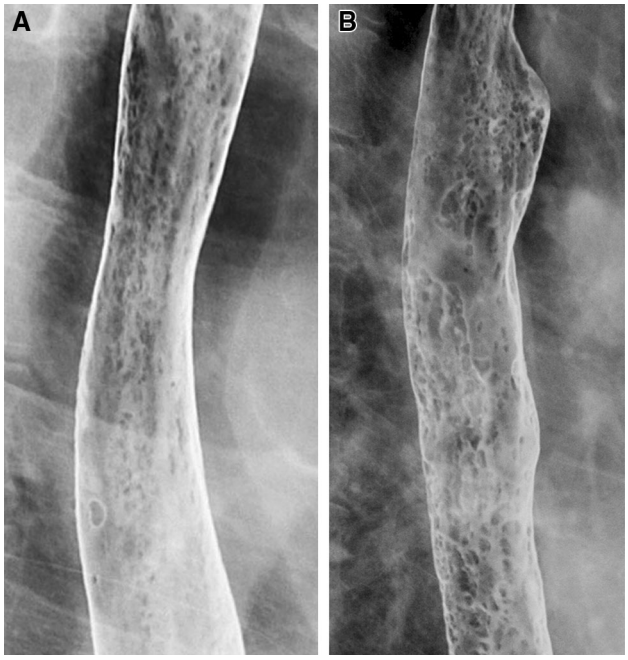

Fig. 3. *Candida* esophagitis with plaques. Upright, left posterior oblique spot image from double-contrast esophagram shows multiple small, discrete plaque-like lesions in the midesophagus. Note that some plaques have linear configuration. Upright, left posterior oblique spot image from double-contrast esophagram shows more advanced *Candida* esophagitis with multiple discrete plaque-like lesions of various sizes and shapes in the midesophagus. The findings in **A** and **B** should be highly suggestive of candidiasis in immunocompromised patients with odynophagia.

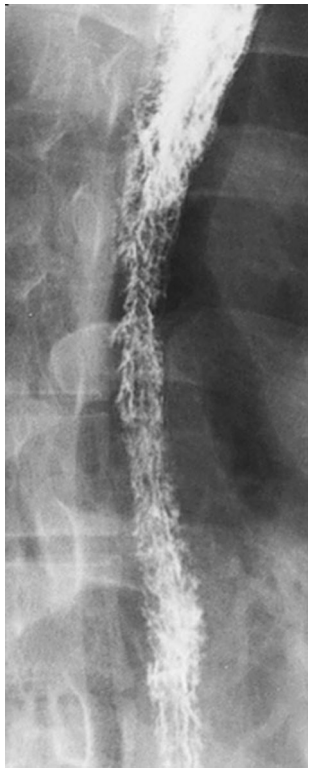

Fig. 4. Advanced *Candida* esophagitis with shaggy esophagus in patient with AIDS. Upright, left posterior oblique spot image from single-contrast esophagram shows grossly irregular (shaggy) esophagus secondary to innumerable plaques and pseudomembranes, with trapping of barium between lesions. This finding is characteristic of fulminant *Candida* esophagitis in patients with AIDS.

views can be obtained while the patient ingests more high-density barium to document the transient nature of this finding (Fig. 8b). Such artifact can also be avoided by obtaining images before administration of effervescent agent when candidiasis is suspected on clinical grounds.

Disease patterns: ulceration

Radiographic findings

Reflux esophagitis

Reflux esophagitis is by far the most common cause of ulceration in the distal esophagus. Some patients have one or more punctate, linear, or irregular ulcers at or near the gastroesophageal junction, whereas others have more extensive ulceration involving the distal third or half of the thoracic esophagus (Fig. 9) [4]. Still other patients have a single dominant ulcer on the posterior wall of the distal esophagus abutting the gastroesophageal junction, presumably because of nocturnal reflux of acid that pools on the posterior wall when patients lie on their backs at night [14]. Conversely, ulcers in reflux esophagitis rarely involve the upper or midesophagus with sparing of the mucosa below, so the presence of one or more ulcers that are confined to the upper or midesophagus should suggest another cause of disease.

Herpes esophagitis

Herpes esophagitis (caused by the herpes simplex virus type 1) usually is manifested on double-contrast studies by small, discrete ulcers in the upper or midesophagus without associated plaques [7, 15, 16]. The ulcers appear as tiny collections of barium, often surrounded by radiolucent mounds of edema (Fig. 10) [7, 15, 16]. In the appropriate clinical setting, the presence of small, discrete ulcers on an otherwise normal background mucosa should be highly suggestive of herpes esophagitis, as ulceration in *Candida* esophagitis only occurs in the setting of a shaggy esophagus.

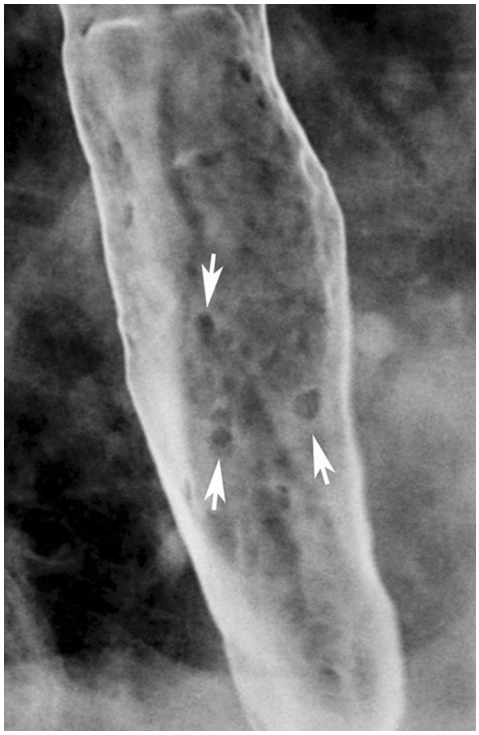

Fig. 5. Glycogenic acanthosis. Upright, left posterior oblique spot image from double-contrast esophagram shows discrete, rounded nodules and plaques (*arrows*) in the midesophagus that could be mistaken for plaque-like lesions of candidiasis. However, glycogenic acanthosis occurs in elderly individuals who are not immunocompromised and have no esophageal symptoms. These conditions therefore usually can be differentiated on clinical grounds.

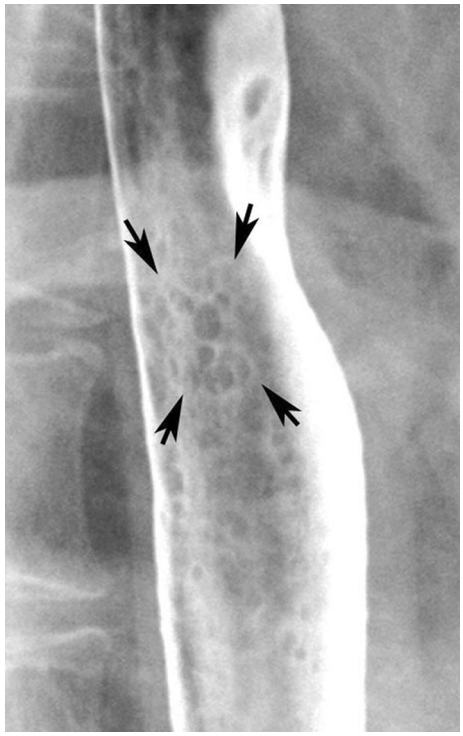

Fig. 6. Superficial spreading carcinoma. Upright, left posterior oblique spot image from double-contrast esophagram shows focal cluster of poorly defined, confluent nodules in the midesophagus (*arrows*). This appearance should be differentiated from the more discrete plaque-like lesions in *Candida* esophagitis.

Herpes esophagitis occasionally may develop in otherwise healthy patients who have no immunologic problems [17]. Double-contrast studies typically reveal multiple punctate ulcers clustered together in the midesophagus below the level of the left main bronchus [17]. The ulcers are even smaller than those in immunocompromised patients with herpes esophagitis, presumably because these individuals have an intact immune system that can prevent the ulcers from enlarging.

Drug-induced esophagitis

The major agents responsible for drug-induced esophagitis include tetracycline and doxycycline, aspirin and other nonsteroidal anti-inflammatory drugs (NSAIDs), quinidine, potassium chloride, and alendronate [18–20]. Affected individuals typically have a history of ingesting the pills or capsules with little or no water before going to bed. As a result, the medication can become lodged in the esophagus where it is compressed by the aortic arch or left main bronchus, causing ulceration of the adjacent esophageal wall. Drug-induced esophagitis usually is manifested on double-contrast esophagrams by small, discrete ulcers in the upper or midesophagus indistinguishable from those in herpes esophagitis (Fig. 11) [18–20]. Rarely, patients with drug-induced esophagitis can develop giant ulcers in the esophagus [20, 21].

Crohn's disease

Aphthoid ulcers occasionally may be found in the esophagus in patients with Crohn's disease involving the small bowel or colon [22]. Like aphthoid ulcers elsewhere in the gastrointestinal tract, they typically appear on double-contrast studies as punctate or slit-like barium collections surrounded by radiolucent mounds of edema [22]. When aphthoid ulcers are detected in patients with abdominal pain and diarrhea, a small bowel follow through may be performed to search for concomitant Crohn's disease in the distal ileum, as eso-

Fig. 7. Reticular pattern of Barrett's esophagus. Upright, right posterior oblique spot image from double-contrast esophagram shows moderate hiatal hernia with mild peptic stricture (*black arrows*) in the distal esophagus and delicate reticular pattern (*white arrows*) above stricture. In the presence of a hiatal hernia and GER, this reticular pattern should be highly suggestive of Barrett's esophagus.

phageal Crohn's disease almost never occurs in the absence of disease elsewhere in the gastrointestinal tract [22].

Cytomegalovirus and human immunodeficiency virus esophagitis

Unlike herpes esophagitis, cytomegalovirus (CMV) esophagitis may be manifested by the development of one or more giant ulcers greater than 1 cm in size [23]. These patients usually are found to have underlying AIDS. Giant esophageal ulcers may also be caused directly by HIV in HIV-positive patients [24, 25]. Both CMV and HIV esophagitis are characterized on barium studies by one or more giant, ovoid or diamond-shaped ulcers, often surrounded by a thin radiolucent rim of edema (Fig. 12) [24, 25]. As herpetic ulcers almost never become this large, the presence of one or more giant ulcers should suggest CMV or HIV esophagitis in HIV-positive patients with odynophagia. Nevertheless, giant HIV ulcers are impossible to differentiate from giant CMV ulcers on the basis of the radiographic findings, so endoscopy is required for a definitive diagnosis [7, 24, 25].

Ulcerated carcinoma

Large benign ulcers in the esophagus must be differentiated from ulcerated esophageal carcinomas, which usually contain irregular areas of ulceration surrounded by a thick rind of tumor rather than the thin radiolucent rim of edema associated with benign ulcers (Fig. 13) [11]. When the radiographic findings are equivocal or suspicious for malignant tumor, endoscopy and biopsy are required for a definitive diagnosis.

Clinical aspects

Ulcers in reflux esophagitis cause heartburn or indigestion rather than true odynophagia, so the presence of odynophagia should suggest other etiologies for the ulcers. In contrast, ulcers associated with viral, drug-induced, or radiation esophagitis typically cause odynophagia. When esophageal ulcers are found on barium studies in these patients, the correct diagnosis usually can be suggested on the basis of the clinical findings (i.e., viral esophagitis in immunocompromised patients; drug-induced esophagitis in patients on known offending medications; and radiation esophagitis in patients with recent radiation therapy to the mediastinum). Occasionally, herpes esophagitis may also develop in patients who are not immunocompromised. These patients typically are young men who have had recent exposure to sexual partners with oropharyngeal herpes [17]. Affected individuals typically present with a flu-like syndrome consisting of fever, headaches, myalgias, and upper respiratory infections for 3–10 days prior to the sudden onset of severe odynophagia [17]. The diagnosis of herpes esophagitis in otherwise healthy patients therefore can be suggested on the basis of the clinical and radiographic findings without need for endoscopy in most cases.

When giant ulcers are encountered in the esophagus in patients with AIDS, the clinical history may be helpful for differentiating CMV from HIV as the underlying cause; patients with CMV esophagitis almost always have advanced AIDS when they develop odynophagia, whereas patients with HIV esophagitis often have odynophagia before they develop AIDS and

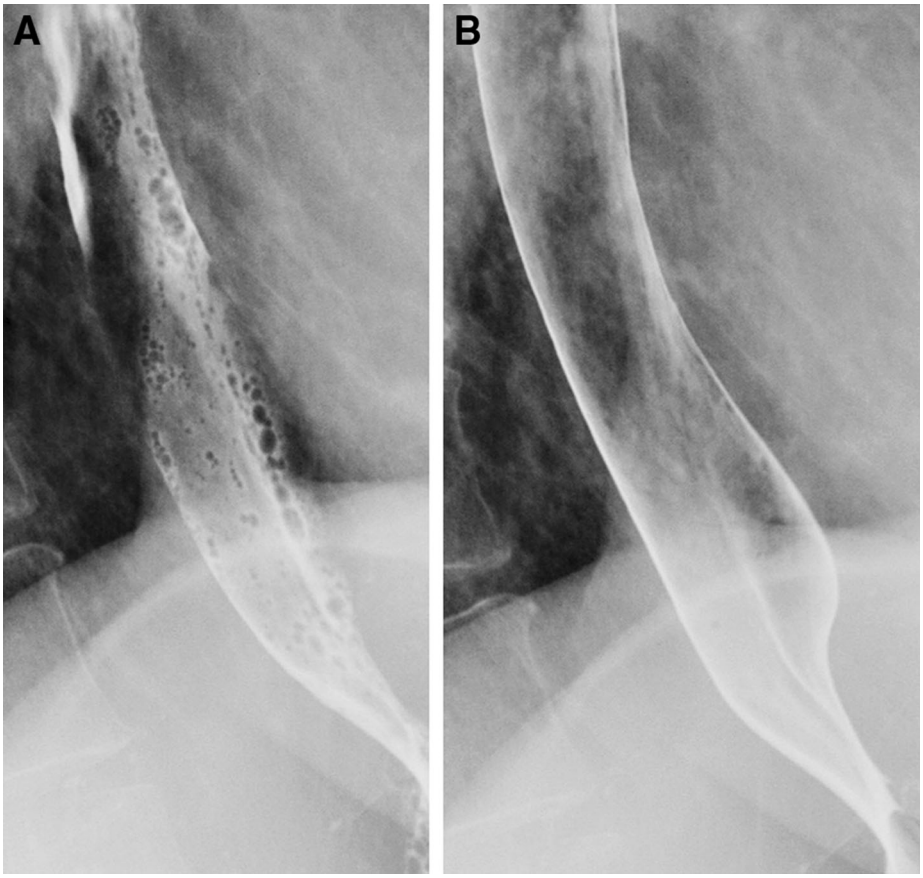

Fig. 8. Undissolved effervescent agent mimicking *Candida* esophagitis. Upright, left posterior oblique spot image from double-contrast esophagram shows undissolved effervescent agent in the distal esophagus, simulating plaque-like lesions of candidiasis. Additional spot image while patient ingests more high-density barium shows normal-appearing distal esophagus, indicating transient nature of artifact.

sometimes have associated ulcers on the palate or a characteristic rash on the upper body [24, 25]. When HIV or CMV esophagitis is suspected on clinical grounds, endoscopy should be performed to differentiate these infections. If CMV esophagitis is confirmed, the patient generally is treated with gancyclovir, a relatively toxic anti-viral agent that causes bone marrow suppression [7]. If brushings, biopsies, and cultures are all negative for CMV, however, the patient is presumed to have HIV esophagitis as a diagnosis of exclusion [7]. The latter patients usually have a marked clinical response to treatment with oral steroids [7]. Thus, endoscopy is required for all HIV-positive patients with giant esophageal ulcers to differentiate CMV from HIV esophagitis, so appropriate therapy can be instituted.

Diagnostic pitfalls

Esophageal intramural pseudodiverticulosis

Dilated excretory ducts of deep mucus glands in the esophagus (also known as esophageal intramural pseudodiverticula) sometimes can be mistaken on barium studies for tiny ulcers. When viewed in profile, the pseudodiverticula typically appear as flask-shaped outpouchings in longitudinal rows parallel to the long axis of the esophagus (Fig. 14) [26]. These pseudodiverticula can be associated with high strictures (see Fig. 14) or, even more commonly, peptic strictures in the distal esophagus [26]. When viewed en face, the pseudodiverticula may appear as tiny barium collections indistinguishable from punctate ulcers (see Fig. 14). When viewed in profile, however, the pseudodiverticula often

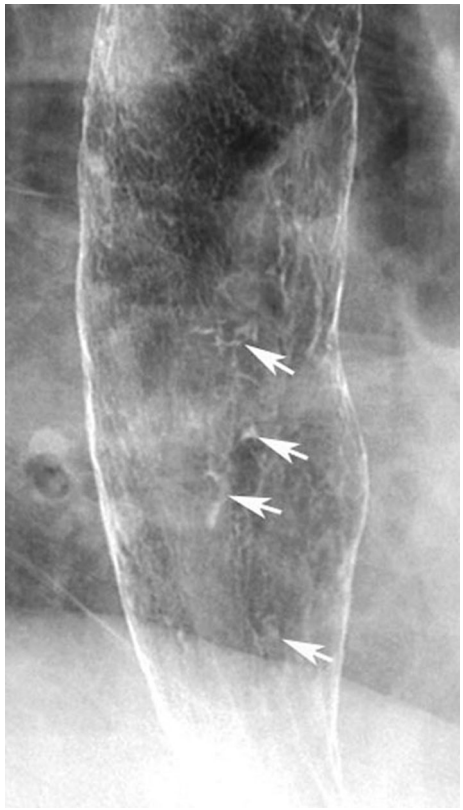

Fig. 9. Reflux esophagitis with ulceration. Upright, left posterior oblique spot image from double-contrast esophagram shows tiny, irregular ulcers (*arrows*) superimposed on background of mucosal granularity in the distal esophagus. This patient had marked reflux esophagitis.

seem to be floating outside the wall of the esophagus, whereas true ulcers almost always communicate directly with the lumen (see Fig. 14) [20, 26].

Ectopic gastric mucosa

Ectopic gastric mucosa is a congenital anomaly unrelated to Barrett's esophagus, in which abnormal embryologic development leads to the development of one or more rests of gastric mucosa in the upper esophagus at or just above the thoracic inlet (hence the name *inlet patch*) [27]. This condition is found as an incidental finding at endoscopy in 4–10% of patients, and the vast majority are asymptomatic [27]. When viewed in profile, ectopic gastric mucosa typically is manifested on barium studies by a broad, flat depression in the upper esophagus at or just above the thoracic inlet (Fig. 15) [28]. As a result, ectopic gastric mucosa sometimes can be mistaken for a large, flat ulcer or even an intramural dissection in the upper esophagus [29], but the typical appearance and location of these lesions should suggest the correct diagnosis.

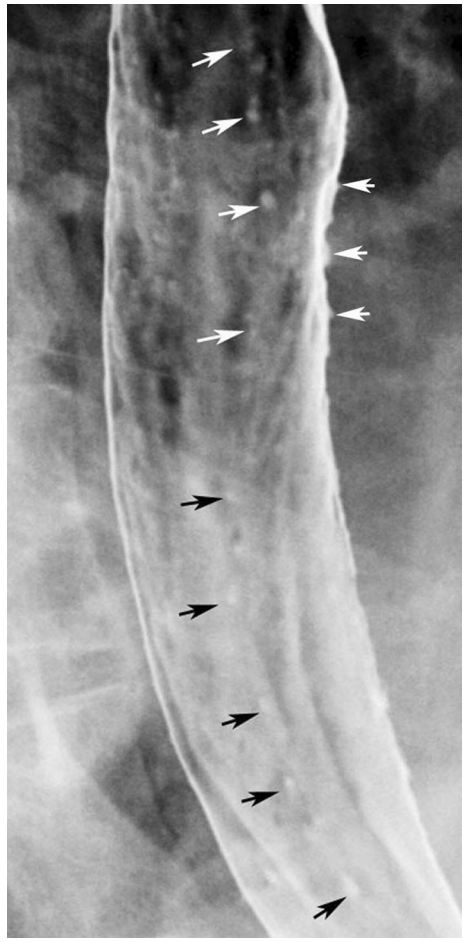

Fig. 10. Herpes esophagitis with ulceration. Upright, left posterior oblique spot image from double-contrast esophagram shows multiple tiny, discrete ulcers en face (*long black* and *white arrows*) and in profile (*short white arrows*) in the mid and distal esophagus in HIV-positive patient with odynophagia.

Artifacts

Tiny areas of ulceration occasionally can be simulated by precipitated barium in the esophagus. When viewed in profile, however, barium precipitates are confined to the lumen, whereas true ulcers project outside the lumen, enabling differentiation of this artifact from true ulcers.

Disease patterns: distal esophageal strictures and rings

Radiographic findings

Scarring from reflux esophagitis is by far the most common cause of stricture formation in the distal esophagus. Reflux-induced strictures (also known as *peptic strictures*) typically appear on barium studies as smooth, tapered areas of concentric narrowing (ranging

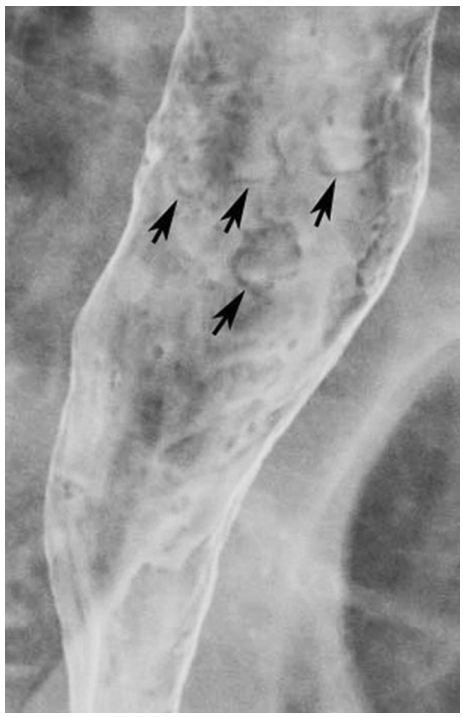

Fig. 11. Drug-induced esophagitis with ulceration. Upright, left posterior oblique spot image from double-contrast esophagram shows multiple discrete ulcers (*arrows*) clustered together in the midesophagus. This patient developed acute onset of odynophagia after taking doxycycline.

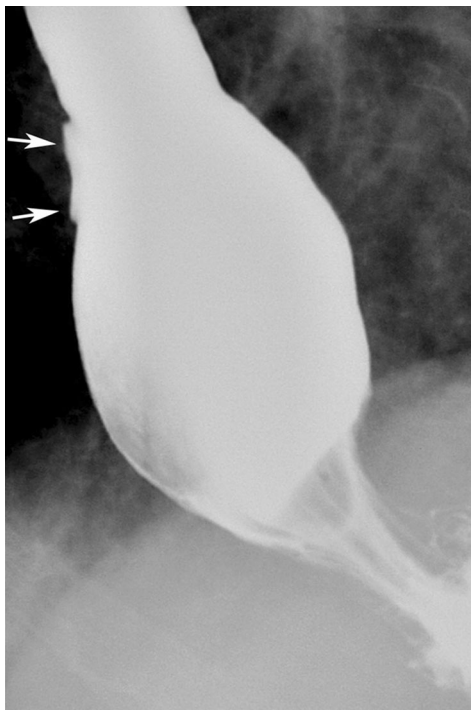

Fig. 12. HIV esophagitis in HIV-positive patient. Upright, left posterior oblique spot image from double-contrast esophagram shows large, flat ulcer (*arrows*) in the distal esophagus abutting hiatal hernia. Endoscopic biopsies, brushings, and cultures were all negative for CMV, so this ulcer was thought to be caused directly by HIV. CMV and HIV ulcers are virtually impossible to differentiate on radiographic criteria, so endoscopy is required for a definitive diagnosis.

from 1 to 4 cm in length) in the distal esophagus above a hiatal hernia (Fig. 16) [4, 30]. Unusually long strictures in the distal esophagus occasionally can result from variants of severe reflux disease secondary to an indwelling nasogastric tube with near-constant GER around the tube (Fig. 17) [4], Zollinger–Ellison syndrome with GER of highly acidic gastric secretions [31], and alkaline reflux esophagitis after a partial or total gastrectomy [32].

Conversely, as many as 40% of peptic strictures appear on barium studies as short, ring-like segments of narrowing that resemble pathologically narrowed lower esophageal rings (also known as *Schatzki rings*) abutting the gastroesophageal junction (Fig. 18) [33]. Schatzki rings appear as smooth, symmetric ring-like constrictions with a vertical height of only 1–4 mm (Fig. 19) [34], whereas ring-like peptic strictures appear as more asymmetric areas of narrowing with a vertical height greater than 4 mm (see Fig. 18) [33]. Thus, it usually is possible to differentiate ring-like peptic strictures from Schatzki rings on the basis of the radiographic findings.

Peptic strictures sometimes can be associated with the development of fixed transverse folds secondary to concomitant longitudinal scarring and shortening of the distal esophagus [35]. These widely spaced folds extend only partway across the circumference of the esophagus; horizontal pooling of barium between the folds produces the *stepladder sign* of scarring from reflux esophagitis (Fig. 20). These fixed transverse folds should be distinguished from the so-called *feline esophagus*, in which delicate transverse folds are seen as closely spaced horizontal striations similar to those normally found in the cat esophagus (Fig. 21) [36]. These transverse folds are seen as a transient finding at fluoroscopy secondary to contraction of the longitudinally oriented muscularis mucosae and almost always are found to be associated with GER [37]. In fact, the feline esophagus is far more likely to be observed when barium refluxes into the esophagus than when barium passes antegrade into the stomach (see Fig. 22) [37].

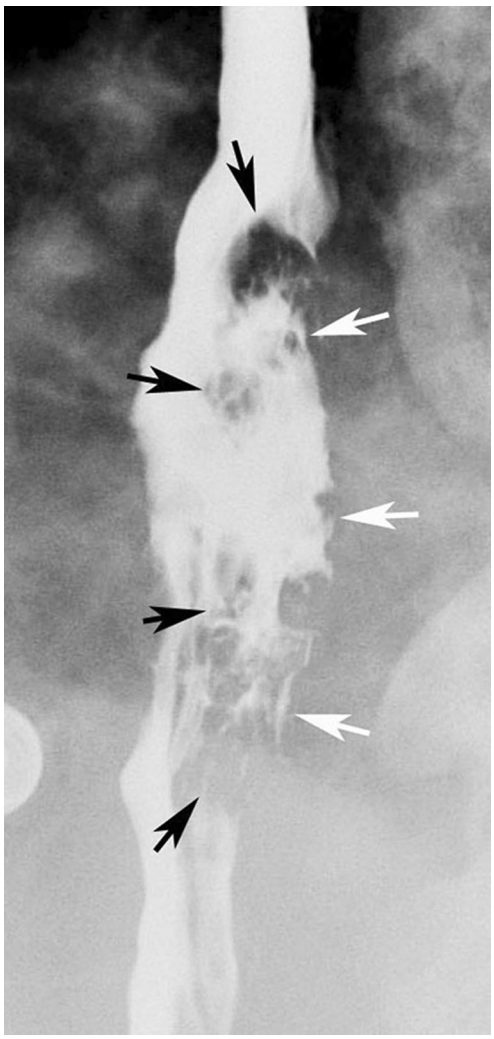

Fig. 13. Ulcerated squamous cell carcinoma of midesophagus. Upright, right posterior oblique spot image from double-contrast esophagram shows large, irregular area of ulceration (*white arrows*) surrounded by thick rind of tumor (*black arrows*). Note how this lesion has very different appearance from HIV ulcer shown in Fig. 12.

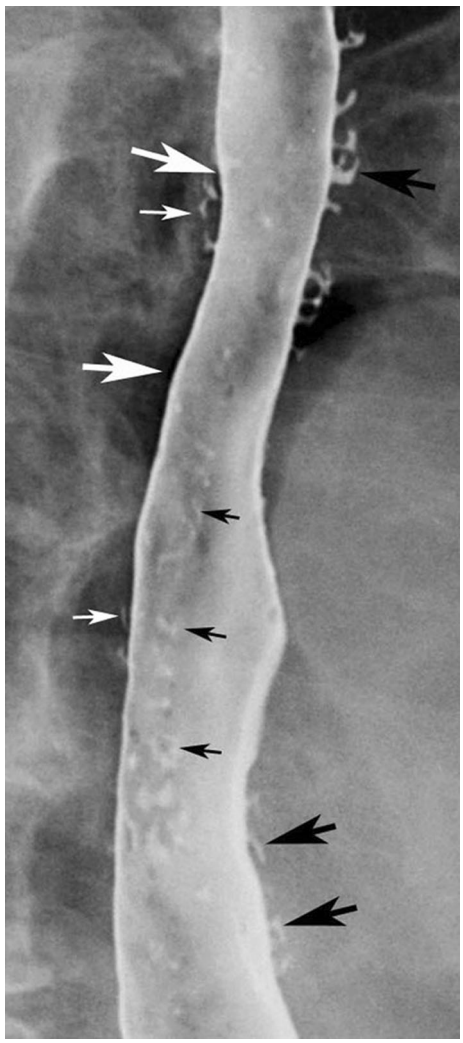

Fig. 14. Esophageal intramural pseudodiverticulosis with high esophageal stricture. Upright, left posterior oblique spot image from double-contrast esophagram shows mild, smooth stricture (*large white arrows*) in the upper thoracic esophagus. Also note esophageal intramural pseudodiverticula as flask-shaped outpouchings (*large black arrows*) from esophagus. When viewed en face, these structures could be mistaken for tiny ulcers (*small black arrows*), but when viewed in profile, some diverticula (*small white arrows*) seem to be floating outside the wall of esophagus, whereas true ulcers communicate directly with lumen.

Benign strictures in the distal esophagus must be differentiated from infiltrating carcinomas, particularly adenocarcinomas arising in Barrett's esophagus, as these lesions predominantly are located in the distal esophagus [11]. Unlike benign strictures, malignant strictures often have an irregular contour and shouldered margins, findings that are worrisome for esophageal carcinoma [11].

Clinical aspects

Patients with peptic strictures typically experience intermittent or gradually progressive dysphagia without substantial weight loss. Similarly, patients with Schatzki rings usually present with a long-standing history of intermittent solid-food dysphagia [34]. Schatzki himself found that rings less than 13 mm in caliber virtually always caused dysphagia, whereas rings between 13 and 20 mm in caliber sometimes caused dysphagia, and rings greater than 20 mm in caliber almost never caused dysphagia [34], so endoscopic dilation of rings is more likely

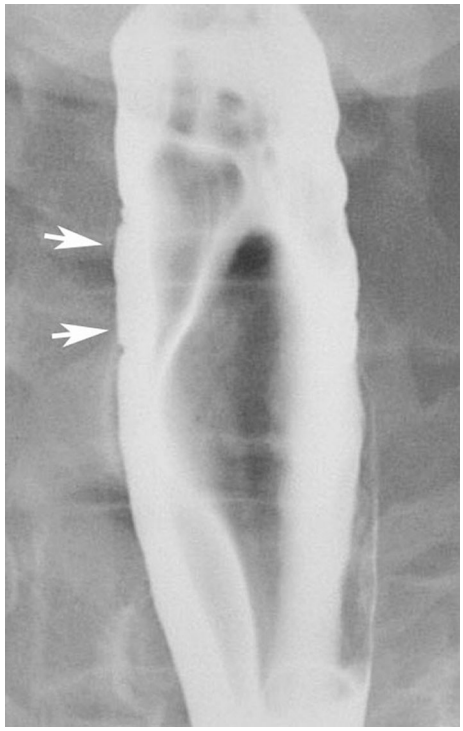

Fig. 15. Ectopic gastric mucosa. Upright frontal spot image from double-contrast esophagram (during rapid sequence imaging) shows broad, flat depression (*arrows*) on the right lateral wall of the upper esophagus just above the thoracic inlet. This finding could be mistaken for a large, flat ulcer, but the typical appearance and location of ectopic gastric mucosa should suggest the correct diagnosis.

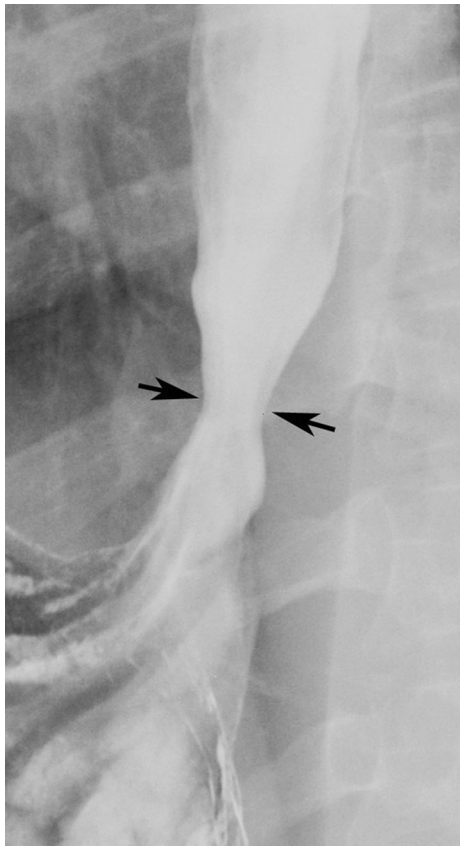

Fig. 16. Peptic stricture. Prone, right anterior oblique spot image from single-contrast esophagram shows smooth, tapered narrowing (*arrows*) of the distal esophagus above a small hiatal hernia. This appearance is characteristic of a reflux-induced (peptic) stricture.

to be needed for rings less than 13 mm in caliber. In contrast, patients with malignant strictures in the distal esophagus typically present with recent onset of dysphagia (less than 3 months) and weight loss, so these findings should raise concern about the possibility of malignant tumor.

Diagnostic pitfalls

It has been shown that prone single-contrast esophagrams are superior to upright double-contrast esophagrams for detecting strictures and rings in the distal esophagus [38], even enabling detection of narrowing that is missed at endoscopy [39, 40]. Optimal distention of the distal esophagus is critical for showing these strictures and rings, as areas of narrowing will be visible only if the adjacent esophagus and hiatal hernia are distended beyond the caliber of the narrowed segment (Fig. 23).

Conversely, strictures and rings abutting the gastroesophageal junction can also be missed if overdistention of this region causes overlap between the lower end of the esophagus and upper end of the adjacent hiatal hernia, preventing visualization of the narrowed segment in profile (Fig. 24a). This so-called *overlap phenomenon* is a known cause of missed strictures and rings abutting the gastroesophageal junction on prone single-contrast views of the distal esophagus [41]. However, overlap can be suspected when a biconvex double-density is observed at the gastroesophageal junction (see Fig. 24a). In such cases, additional views should be obtained with the esophagus less distended or in a different projection to prevent overlap and visualize the narrowed segment in profile (Fig. 24b) [41]. When these views fail to show distal strictures or rings because of persistent overlap, retention of an administered 12-mm barium tablet at the site of overlap should be highly suggestive of a short segment of narrowing even if the narrowing is not directly visualized (Fig. 24c). Endoscopy can then be performed for further evaluation.

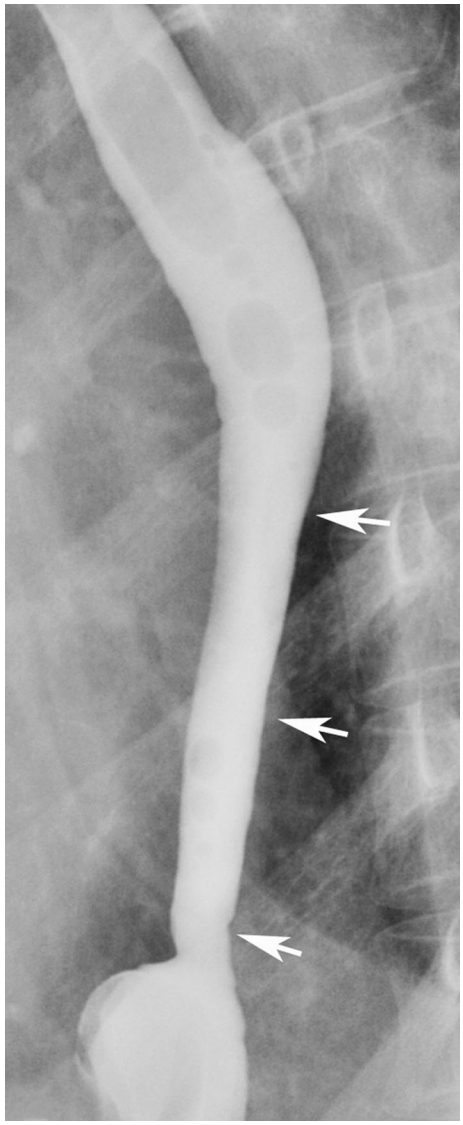

Fig. 17. Nasogastric tube stricture. Prone, right anterior oblique spot image from single-contrast esophagram shows long segment of smooth narrowing (*arrows*) in the distal esophagus secondary to scarring from marked gastroesophageal reflux around indwelling nasogastric tube. Strictures associated with alkaline reflux esophagitis and Zollinger–Ellison syndrome could produce similar findings.

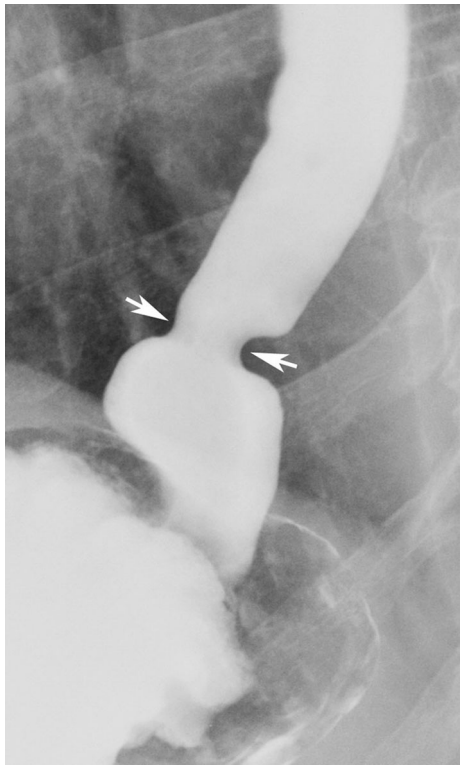

Fig. 18. Ring-like peptic stricture. Prone, right anterior oblique spot image from single-contrast esophagram shows short segment of narrowing (*arrows*) in the distal esophagus that resembles Schatzki ring, but this stricture has slightly greater vertical height and is more asymmetric than the typical Schatzki ring (see Fig. 19).

Disease patterns: upper or mid esophageal strictures

Radiographic findings

Benign strictures in the upper or midesophagus may be caused by mediastinal irradiation, Barrett's esophagus, eosinophilic esophagitis, caustic ingestion, drug-induced esophagitis, or unusual bullous conditions involving the esophagus [4, 20]. The radiographic features often are helpful for suggesting the correct diagnosis.

Radiation strictures typically appear on barium studies as long segments of smooth, tapered narrowing within a preexisting radiation portal (Fig. 25) [20]. In contrast, Barrett's esophagus may be manifested by short, ring-like or smooth, tapered strictures in the midesophagus at or below the aortic arch (Fig. 26) [4]. These patients often have other findings of reflux disease, including hiatal hernias, GER, and reflux esophagitis. Strictures from eosinophilic esophagitis appear as variably long segments of narrowing in the upper or midesophagus, sometimes associated with distinctive ring-like indentations in the region of narrowing, producing the so-called *ringed esophagus* of eosinophilic esophagitis (Fig. 27) [42]. Healing of large drug-induced ulcers caused by NSAIDs, potassium chloride, and quinidine can also lead to the develop-

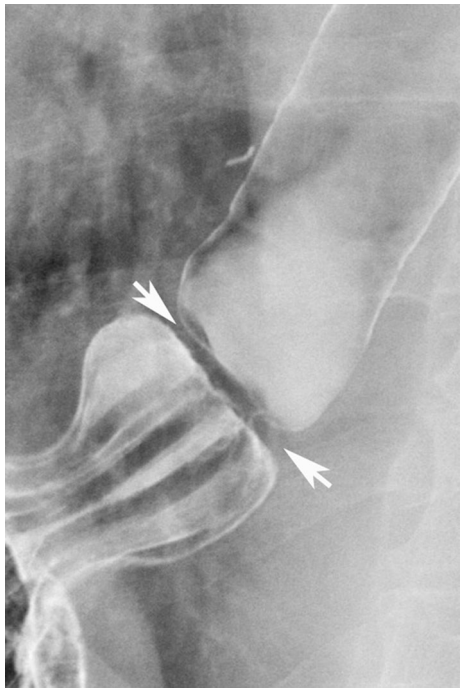

Fig. 19. Schatzki ring. Prone, right anterior oblique spot image from single-contrast esophagram shows smooth, symmetric ring-like constriction (*arrows*) above a hiatal hernia. Note how the ring has a vertical height of only 2–3 mm. In contrast, a ring-like peptic stricture tends to be longer and more asymmetric (see Fig. 18).

Fig. 20. Peptic stricture with fixed transverse folds. Prone, right anterior oblique spot image from single-contrast esophagram shows smooth, eccentric stricture (*white arrow*) in the distal esophagus above a hiatal hernia. Also note horizontal pooling of barium between fixed transverse folds (*black arrows*) abutting proximal end of stricture, producing classic stepladder sign of longitudinal scarring/shortening from reflux esophagitis.

ment of short, ring-like or smooth, tapered strictures in the upper or midesophagus (Fig. 28) [20, 43]. In contrast, lye strictures may be manifested by unusually long, irregular segments of narrowing in the cervical and thoracic esophagus [20]. Finally, benign mucus membrane pemphigoid and epidermoid bullosa dystrophica can be associated with the development of webs or strictures in the upper esophagus [20].

Benign causes of stricture formation in the upper or midesophagus must be differentiated from infiltrating esophageal carcinomas, particularly squamous cell carcinomas. Unlike benign strictures, however, malignant strictures are characterized by irregular luminal narrowing with nodular, lobulated, or ulcerated contours and abrupt or shelf-like margins (Fig. 29) [11]. It has been shown that unequivocally benign-appearing strictures are virtually always benign [33], so endoscopy and biopsy are required only for strictures that have an equivocal or suspicious appearance.

Clinical aspects

The clinical presentation is extremely helpful for differentiating benign and malignant strictures in the upper or midesophagus. Patients with benign strictures usually have chronic or intermittent dysphagia that progresses slowly and is not associated with substantial weight loss, whereas patients with malignant strictures present with recent onset (less than 3 months) of worsening dysphagia and weight loss [11]. It also is important to recognize that dysphagia frequently is referred upwards (but never downwards), so patients with a sensation of food getting stuck in the throat can have abnormalities in the distal esophagus or even at the gastric cardia as the cause of their dysphagia [44]. It therefore is important to evaluate the distal esophagus and gastric cardia in all patients with dysphagia, regardless of its subjective localization.

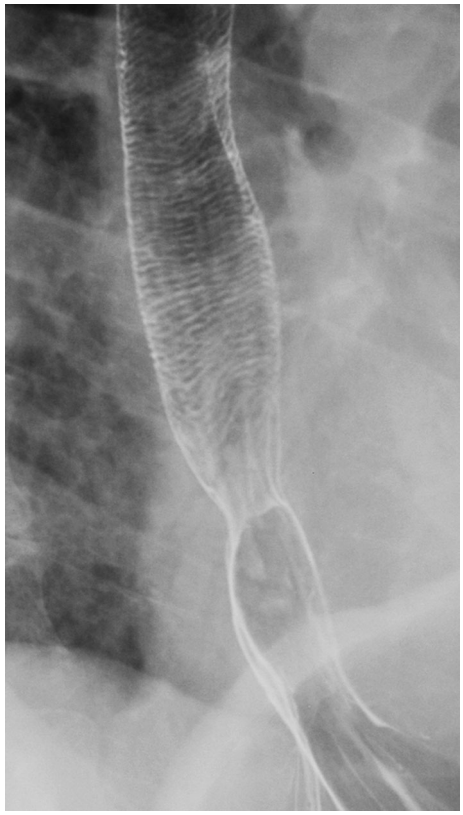

Fig. 21. Feline esophagus. Upright, left posterior oblique spot image from double-contrast esophagram shows multiple delicate transverse folds extending completely across circumference of lower thoracic esophagus (also known as feline esophagus). These folds were not seen on repeat spot image moments later. The feline esophagus results from transient contraction of longitudinally oriented muscularis mucosae.

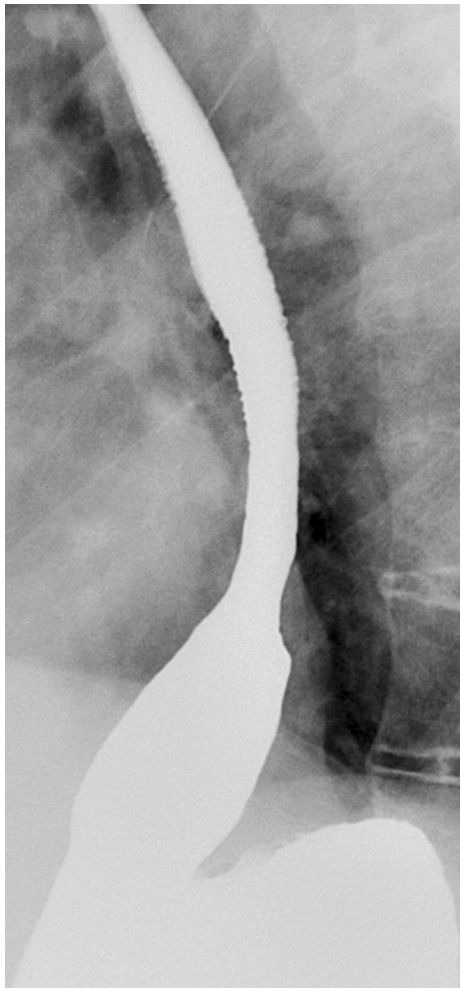

Fig. 22. Association of feline esophagus with gastroesophageal reflux. Note the delicate transverse striations in esophagus while barium refluxes from stomach. The feline esophagus is much more likely to be observed when barium refluxes from stomach than when it is swallowed.

When benign-appearing strictures are present in the upper of midesophagus, the clinical history often is helpful for suggesting the correct diagnosis. Radiation strictures typically develop 1 year or more after radiation therapy to the mediastinum [20]. In contrast, Barrett's strictures should be suggested by the presence of a hiatal hernia and GER in patients with a history of reflux disease, whereas eosinophilic esophagitis should be suspected in young men with long-standing dysphagia and intermittent food impactions, sometimes associated with an atopic history, asthma, or peripheral eosinophilia [42]. Patients with caustic strictures often are known to have accidentally or intentionally ingested strong acids or alkali in the past, whereas drug-induced strictures should be suspected in patients with a history of taking medications known to cause drug-induced esophagitis. Finally, benign mucus membrane pemphigoid and epidermolysis bullosa dystrophica should be considered in patients with known bullous disease of the skin or mucus membranes.

Diagnostic pitfalls

The esophagus adjacent to a stricture in the upper or midesophagus must be distended beyond the caliber of the stricture for the stricture to be visualized on barium studies. Prone views of the esophagus with continuous drinking of low-density barium therefore are essential for optimizing detection of strictures by increasing esophageal distention. Even with this technique, however, strictures can be missed if esophageal distention is inadequate. When the esophagus is not well distended,

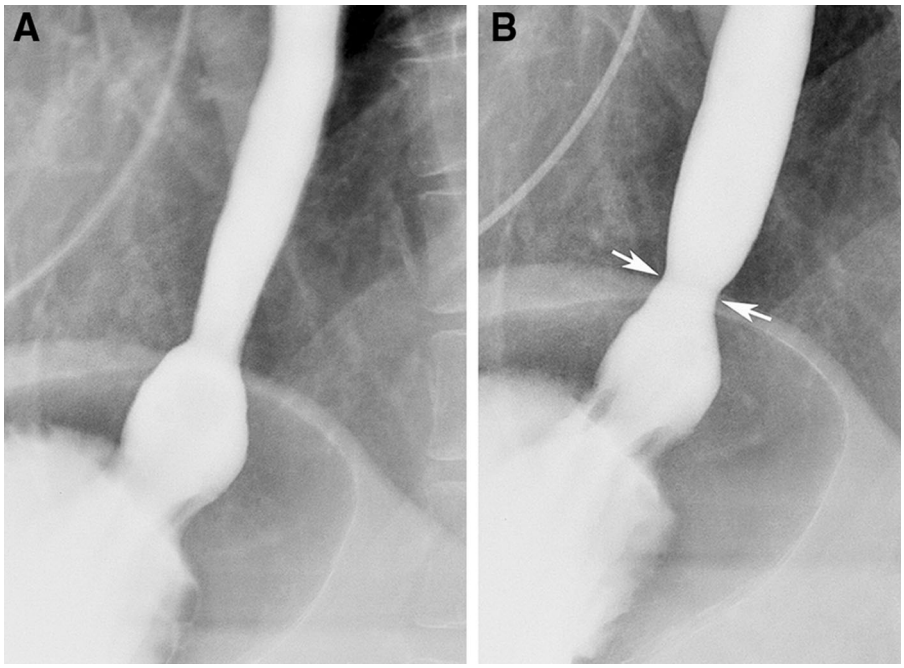

Fig. 23. Importance of esophageal distention for visualizing strictures in the distal esophagus. Prone, right anterior oblique spot image from single-contrast esophagram shows small hiatal hernia without apparent narrowing of distal esophagus. Additional spot image with greater distention shows smooth, tapered peptic stricture (*arrows*) in the distal esophagus that is visualized only when esophagus above the stricture and hernia below the stricture are distended beyond caliber of stricture. This case illustrates the importance of obtaining prone spot images with optimal distention of distal esophagus to avoid missing strictures or rings in this location.

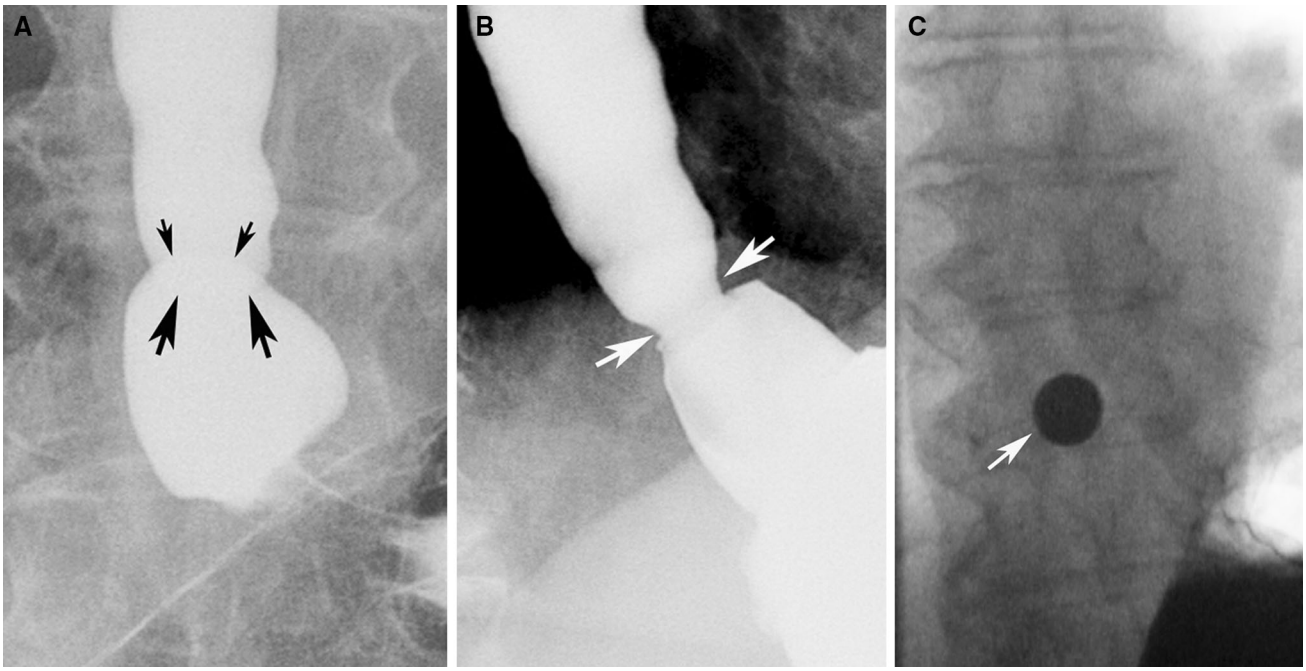

Fig. 24. Importance of avoiding overlap for visualizing strictures in the distal esophagus. Supine spot image from single-contrast esophagram shows small hiatal hernia without apparent narrowing of distal esophagus. However, note the overlap between the distal end of esophagus and top of hernia, producing biconvex double-density (*arrows*) that prevents visualization of gastroesophageal junction in profile. Additional left posterior oblique spot image with slightly less distention of distal esophagus shows short peptic stricture (*arrows*) that was not visible on earlier radiograph because of overlap phenomenon. Captured fluoroscopic image after ingestion of 12-mm barium tablet shows retention of tablet (*arrow*) at level of stricture shown in **B**.

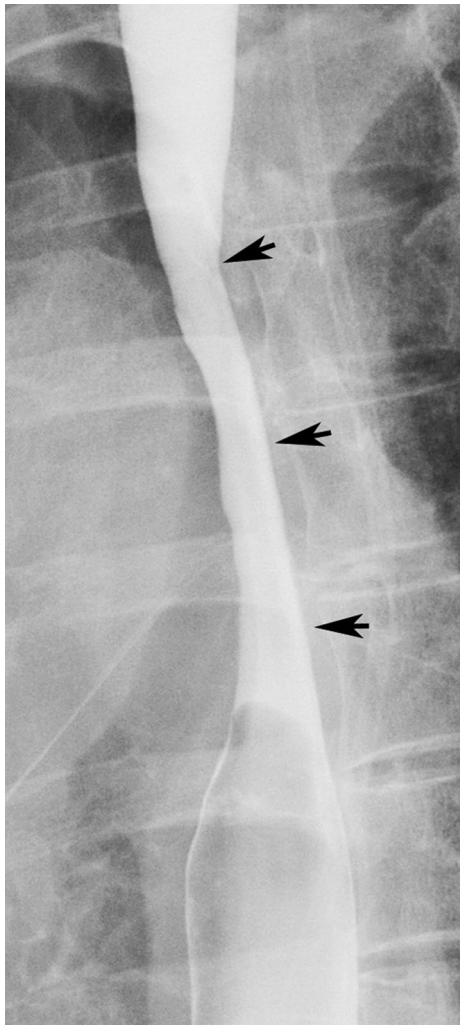

Fig. 25. Radiation stricture. Prone, right anterior oblique spot image from single-contrast esophagram shows long segment of narrowing with smooth contours and tapered margins (*arrows*) in the midthoracic esophagus. This patient developed dysphagia 2 years after receiving mediastinal irradiation for lung cancer.

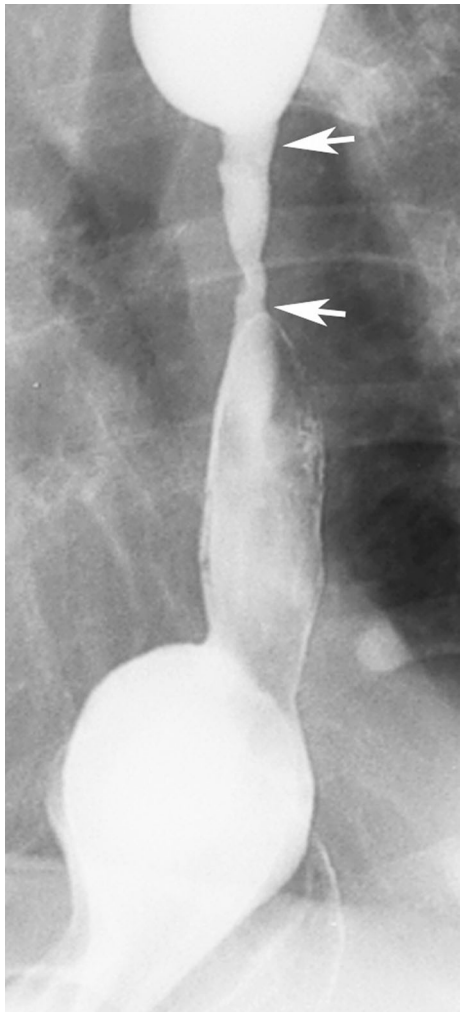

Fig. 26. Barrett's esophagus with midesophageal stricture. Prone, right anterior oblique spot image from single-contrast esophagram shows hiatal hernia with smooth, tapered segment of narrowing (*arrows*) in the midesophagus. In the presence of a hiatal hernia and gastroesophageal reflux, a midesophageal stricture should be highly suggestive of Barrett's esophagus.

additional views with more rapid drinking of barium may be required to detect subtle areas of narrowing.

Disease patterns: diffuse narrowing of the esophagus (small-caliber esophagus)

Radiographic findings

A small-caliber esophagus is characterized on esophagrams by smooth, long-segment narrowing of the entire or nearly entire cervical and thoracic esophagus. This finding should be differentiated from a segmental stricture with discrete proximal and distal margins. The thoracic esophagus usually has a caliber greater than 2 cm, whereas a small-caliber esophagus often has a caliber less than 1 cm [45]. This finding classically is thought to be characteristic of eosinophilic esophagitis (Fig. 30) [45], but lichen planus, a chronic inflammatory condition involving the skin, mucus membranes, and esophagus, recently has been recognized on barium studies as another cause of a small-caliber esophagus indistinguishable from eosinophilic esophagitis (Fig. 31) [46]. A lye stricture involving the esophagus may also be manifested by long-segment esophageal narrowing, resembling the small-caliber esophagus of eosinophilic

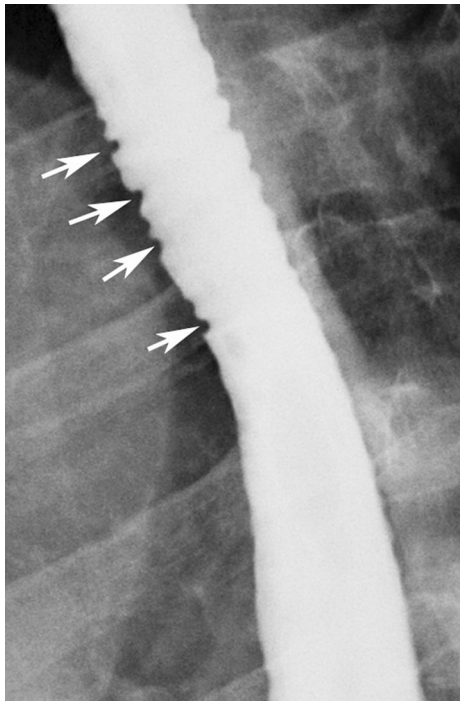

Fig. 27. Ringed esophagus of eosinophilic esophagitis. Prone, right anterior oblique spot image from single-contrast esophagram shows segment of mild narrowing in the upper thoracic esophagus with distinctive ring-like indentations (*arrows*) characteristic of eosinophilic esophagitis.

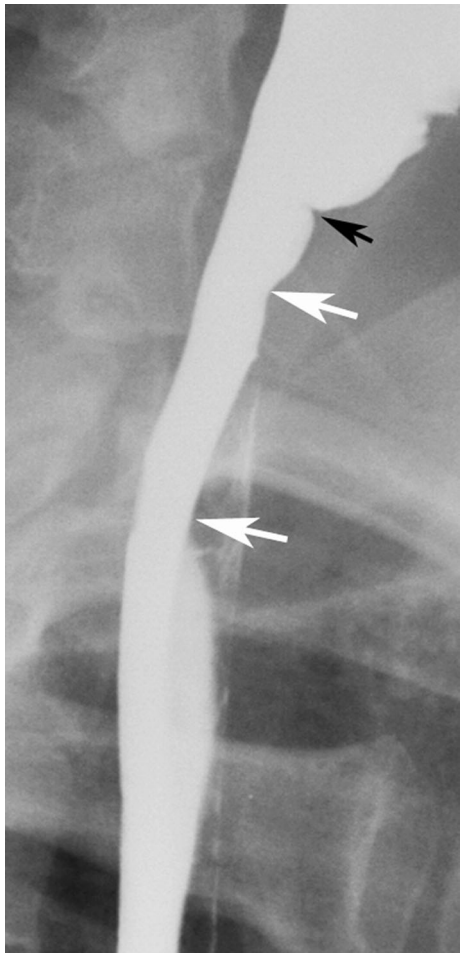

Fig. 28. Drug-induced stricture. Upright, left posterior oblique spot image from double-contrast esophagram shows smooth stricture (*white arrows*) in the upper esophagus, with minimal anterior web (*black arrow*) abutting superior aspect of stricture. This patient had acute odynophagia after taking ibuprofen and then presented with dysphagia 4 months later secondary to development of drug-induced stricture.

esophagitis or lichen planus (Fig. 32). In patients with lye strictures, however, the residual lumen can have a more irregular contour and, in severe disease, a caliber of only several millimeters [20].

Clinical aspects

Eosinophilic esophagitis is a chronic inflammatory disease typically affecting young men with long-standing dysphagia, recurrent food impactions, and an atopic history, asthma, or peripheral eosinophilia [42, 45]. This condition has been diagnosed with much greater frequency over the past two decades, either because of an increased prevalence of disease, an increased awareness, or, more likely, a combination of both. The diagnosis can be established on endoscopic biopsies showing a markedly increased number of intraepithelial eosinophils in the esophagus [42, 45].

Unlike eosinophilic esophagitis, esophageal lichen planus occurs predominantly in elderly women with long-standing dysphagia [46, 47]. As many as 50% of patients with lichen planus involving the esophagus experience dysphagia before developing skin disease [47], so lichen planus may not be suspected at the time of clinical presentation. Nevertheless, the age and sex of the patient and the absence of an atopic history, asthma, or peripheral eosinophilia often enable differentiation of lichen planus from eosinophilic esophagitis. The diagnosis can be established on endoscopic biopsies showing a lymphocyte infiltrate with keratinocyte degeneration, prominent Civatte bodies (i.e., necrotic keratinocytes), and few or no intraepithelial eosinophils [46, 47].

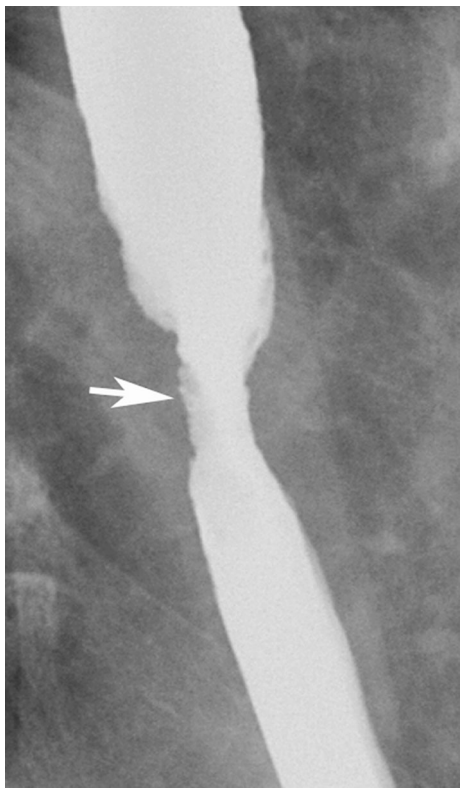

Fig. 29. Infiltrating squamous cell carcinoma of midesophagus. Upright, left posterior oblique spot image from double-contrast esophagram shows short, asymmetric segment of narrowing in the midesophagus (*arrow*) with irregular contour and abrupt proximal margin. These findings are worrisome for malignant tumor.

Differentiation of eosinophilic esophagitis from lichen planus involving the esophagus has important implications for patient management, as patients with eosinophilic esophagitis usually are treated with oral or aerosolized steroids [42, 45], whereas patients with esophageal lichen planus may receive toxic immunosuppressive agents (e.g., methotrexate or cyclosporine) if they fail to respond to steroid therapy [46, 47]. Occasional cases of esophageal carcinoma have been reported in patients with esophageal lichen planus [46], whereas eosinophilic esophagitis is not known to be associated with the development of esophageal cancer.

Diagnostic pitfalls

A small-caliber esophagus occasionally may be simulated by inadequate esophageal distention in patients who take only small sips of barium or swallow the barium too slowly. In such cases, additional views of the esophagus during more rapid swallowing of barium can improve esophageal distention, enabling differentiation from a small-caliber esophagus.

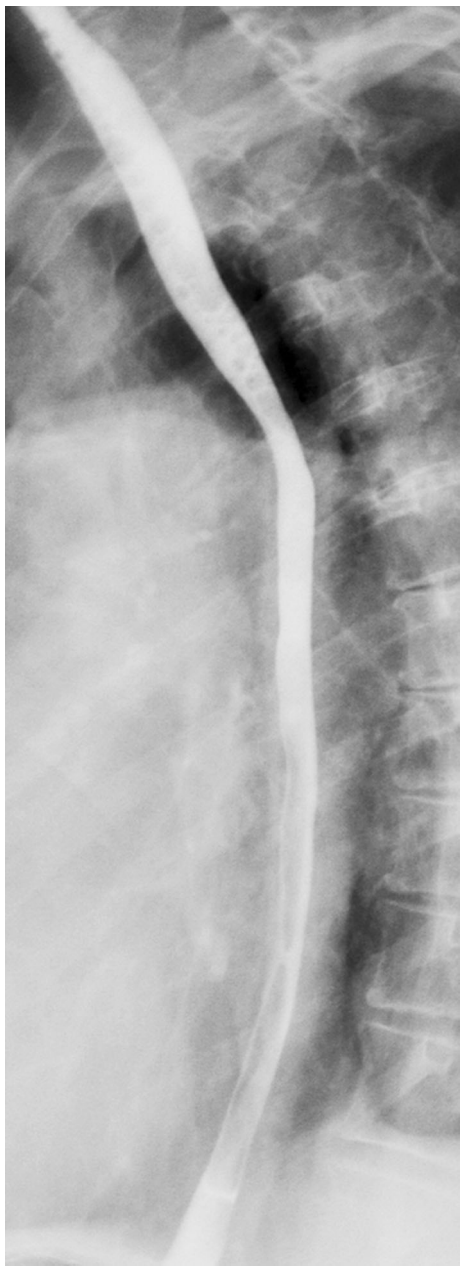

Fig. 30. Small-caliber esophagus of eosinophilic esophagitis. Prone, right anterior oblique spot image from single-contrast esophagram shows marked loss of caliber of entire thoracic esophagus. This young man presented with long-standing dysphagia, asthma, and atopic history. The radiographic and clinical findings should be highly suggestive of eosinophilic esophagitis.

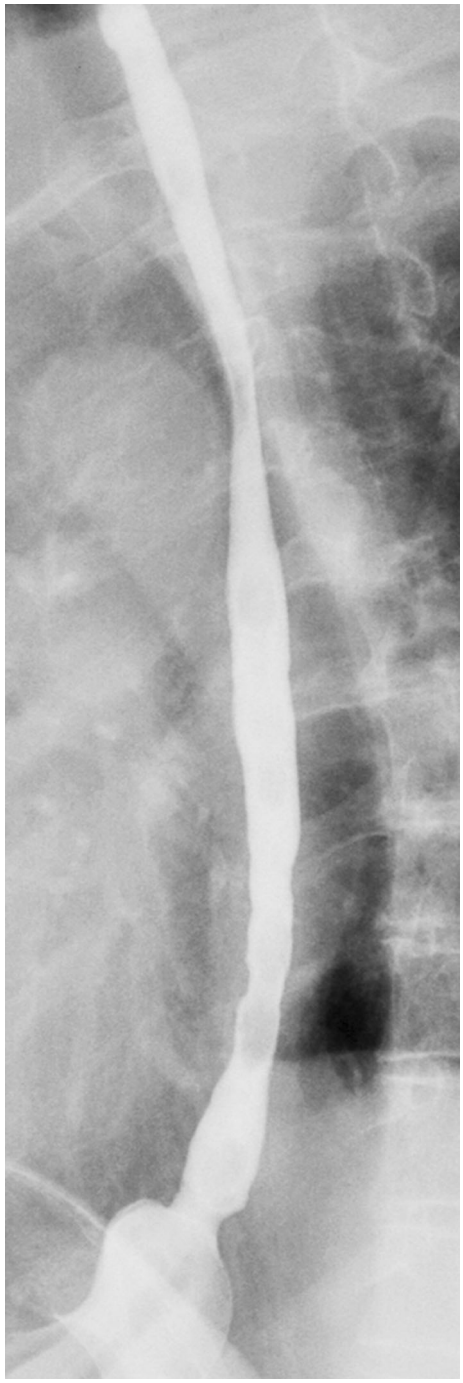

Fig. 31. Small-caliber esophagus of lichen planus. Prone, right anterior oblique spot image from single-contrast esophagram shows smooth narrowing of entire thoracic esophagus indistinguishable from small-caliber esophagus in patient with eosinophilic esophagitis (see Fig. 30). However, this elderly woman had skin disease, and biopsies from esophagus revealed lichen planus. The clinical history is essential for differentiating lichen planus from eosinophilic esophagitis when a small-caliber esophagus is detected on barium studies.

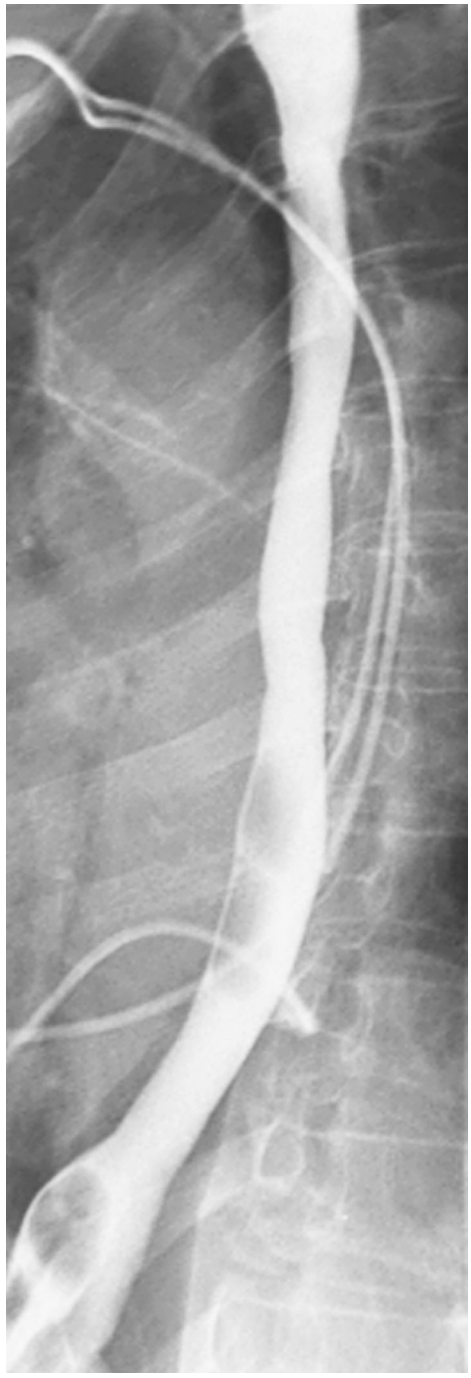

Fig. 32. Chronic lye stricture. Prone, right anterior oblique spot image from single-contrast esophagram shows smooth but variable narrowing of thoracic esophagus, resembling small-caliber esophagus of eosinophilic esophagitis and lichen planus shown in Figs. 30 and 31.

Compliance with ethical standards

Conflict of interest Dr.'s Levine and Rubesin are both consultants for Bracco Diagnostics, Inc. The authors declare that they have no other conflicts of interest.

Ethical approval This is a review article and not a study involving procedures on human participants or animals performed by any of the authors.

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