RADIOLOGIC IMAGING OF GASTROESOPHAGEAL REFLUX DISEASE

M. S. Levine

Gastrointestinal Radiology, Department of Radiology, Hospital of the University of Pennsylvania, University of Pennsylvania School of Medicine, Philadelphia, PA, USA

Introduction

Gastroesophageal reflux disease (GERD) is a ubiquitous problem in modern medical practice; 20% of Americans experience heartburn on a weekly basis [1]. In the past, barium studies have been advocated for patients with reflux symptoms primarily to document the presence of a hiatal hernia or gastroesophageal reflux (GER), to detect complications such as deep ulcers or strictures, and to rule out other organic or motor abnormalities in the esophagus. By permitting a more detailed assessment of the esophageal mucosa, however, double-contrast radiographic techniques have made it possible to detect superficial ulceration and other changes of mild or moderate esophagitis before the development of deep ulcers or strictures. Double-contrast esophagography is also a useful screening examination for Barrett's esophagus to determine the relative need for endoscopy and biopsy in these patients. With double-contrast techniques, barium studies therefore have a major role in the evaluation of patients with known or suspected GERD.

Gastroesophageal reflux

Ambulatory 24-hour esophageal pH monitoring is currently accepted as the gold standard for the detection of GER, with a sensitivity and specificity of greater than 95% [2], [3]. In contrast, barium studies have been found to have relatively limited value in detecting GER, with a reported overall sensitivity of only about 35% [4]. The frequent inability to demonstrate reflux at fluoroscopy in patients with GERD is at least partly related to the observation that reflux often results from transient relaxations of the lower esophageal sphincter rather than from a sustained decrease in sphincter pressure [5], [6]. Provocative tests such as the water siphon test have been shown to increase the sensitivity of the barium study for the detection of GER, but these techniques also result in a lower specificity, compromising the overall accuracy of the radiologic examination [7], [8].

Despite the limitations of barium studies in detecting GER, a recent study found that virtually all patients with massive GER at fluoroscopy (defined as reflux of barium to or above the thoracic inlet with the patient in the recumbent position) had pathologic acid reflux on 24-hour esophageal pH monitoring in the recumbent position [9]. In this study, patients with massive GER on barium studies also had an abnormally low pH for a significantly greater percentage of time than those in a control group. Such work suggests that patients with massive reflux on barium studies are so likely to have pathologic acid reflux in the recumbent position that these individuals can be further evaluated and treated for their reflux disease without need for pH monitoring.

Hiatal hernias

Sliding hiatal hernias occur with greater frequency in older patients as a result of a degenerative process in which there is progressive weakening and laxity of the ligaments that anchor the gastroesophageal junction to the surrounding esophageal hiatus of the diaphragm [10]. There is considerable controversy about the relationship between hiatal hernias and the development of GERD. Because most patients with clinically significant reflux disease have evidence of a hiatal hernia, it has been postulated that a hernia predisposes to the development of GER and that it has a permissive role

in the development of reflux esophagitis [11], [12]. Nevertheless, many patients with a hiatal hernia have no evidence of GER, and many patients with GER have no evidence of a hiatal hernia [13]–[15]. Investigators therefore believe that intrinsic dysfunction of the lower esophageal sphincter is probably the major factor in the development of GER, independent of the anatomic location of the sphincter above or below the diaphragm [14], [16]–[18].

Reflux esophagitis

Conventional single-contrast esophagography has been considered to be an unreliable technique for detecting reflux esophagitis, with an overall sensitivity of only 50–75% [19]–[22]. On the other hand, the use of double-contrast esophagography has increased the radiographic sensitivity to almost 90% [20], [22], [23]. A major advantage of the double-contrast technique is that it permits a detailed assessment of the esophageal mucosa for superficial ulceration or other changes of mild or moderate esophagitis that cannot be detected on single-contrast barium studies. Nevertheless, single-contrast technique (with the patient ingesting barium in the prone position) is best for demonstrating areas of decreased distensibility resulting from lower esophageal rings or strictures. A biphasic examination with upright double-contrast views and prone single-contrast views of the esophagus therefore appears to be the best radiologic technique for evaluating patients with suspected reflux disease.

Abnormal esophageal motility

Between 25 and 50% of patients with reflux esophagitis have abnormal esophageal motility, manifested by intermittently decreased or absent primary peristalsis in the middle or lower thirds of the thoracic esophagus [24]–[26]. In this author's experience, such esophageal dysmotility is rarely associated with nonperistaltic contractions, whereas esophageal dysmotility in the elderly is usually characterized by decreased primary peristalsis with multiple nonperistaltic contractions (the latter condition has been called "presbyesophagus") [27]. Thus, in young patients, the presence of intermittently weakened or absent primary peristalsis without nonperistaltic contractions should be highly suggestive of GERD on barium studies.

Much less frequently, esophageal aperistalsis may be the only radiographic finding in patients with reflux disease [28]. Abnormal motility may be secondary to neuronal damage in Auerbach's plexus caused by direct extension of the inflammatory process into the esophageal wall [28]. Conversely, pre-existing esophageal dysmotility (such as that associated with esophageal involvement by scleroderma) may predispose patients to the development of reflux esophagitis by impairing clearance of refluxed peptic acid from the esophagus. In either case, the combination of abnormal motility and GER produces a vicious cycle, often leading to progressively severe esophagitis [17].

Mucosal nodularity

Early reflux esophagitis may be manifested on double-contrast studies by a finely nodular or granular appearance caused by mucosal edema and inflammation in the distal third or half of the thoracic esophagus (*Fig. 1*) [29]–[31]. This granularity is characterized by tiny radiolucencies with poorly defined borders that fade peripherally into the adjacent mucosa. Less frequently, reflux esophagitis may be manifested by coarse nodularity of the mucosa. In almost all cases, the granularity or nodularity extends proximally from the gastroesophageal junction as a continuous area of disease.

More advanced reflux esophagitis may occasionally be associated with inflammatory exudates or pseudomembranes that resemble the plaquelike lesions of *Candida* esophagitis (*Fig. 2*) [32]. However, these patients usually present with reflux symptoms rather than odynophagia. A single large pseudomembrane can also be mistaken for a plaquelike carcinoma, particularly an adenocarcinoma arising in Barrett's mucosa [32]. However, pseudomembrane formation may be suggested by the presence of other satellite lesions or by a change in the size and shape of the lesions at fluoroscopy.

Ulceration

Shallow ulcers and erosions associated with reflux esophagitis may be seen on double-contrast studies as tiny collections of barium at or near the gastroesophageal junction (*Fig. 3*) [29], [30], [33]. The ulcers can

have a punctate, linear, or stellate configuration and are often associated with surrounding halos of edematous mucosa, radiating folds, or sacculation of the adjacent esophageal wall [29], [30], [33]. When superficial ulceration is detected in patients with reflux esophagitis, the correct diagnosis is almost always suggested by the distal location of the ulcers, the presence of a hiatal hernia or gastroesophageal reflux, and the clinical presentation. Some patients may have relatively diffuse ulceration of the distal third or even half of the thoracic esophagus (*Fig. 4*). However, ulceration in reflux esophagitis tends to occur as a continuous area of disease extending proximally from the gastroesophageal junction, so the presence of one or more ulcers in the middle third of the esophagus with sparing of the distal third should suggest another cause for the patient's disease.

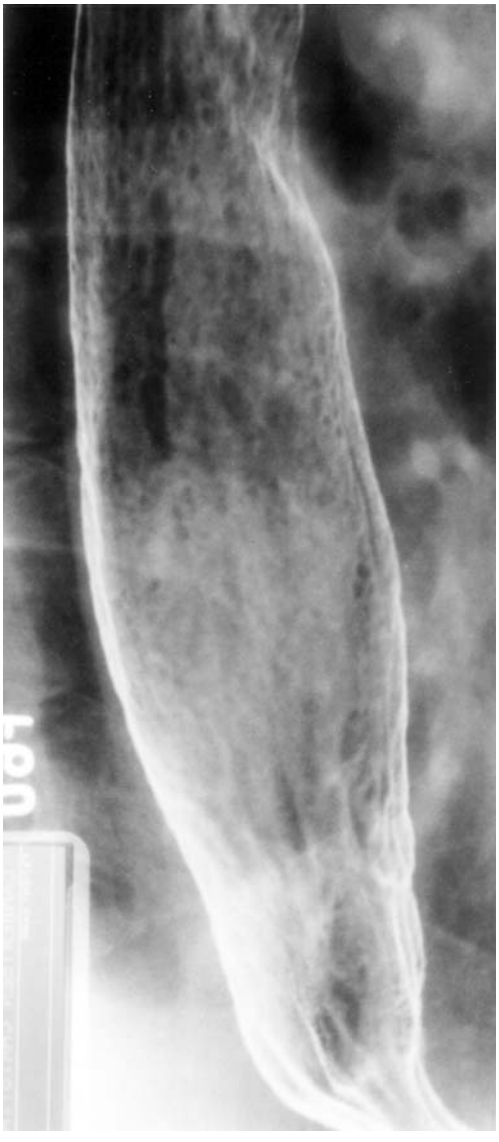

Fig. 1. Reflux esophagitis with granular mucosa. Note finely nodular or granular appearance in the lower third of the esophagus with poorly defined radiolucencies that fade peripherally as a result of mucosal edema and inflammation

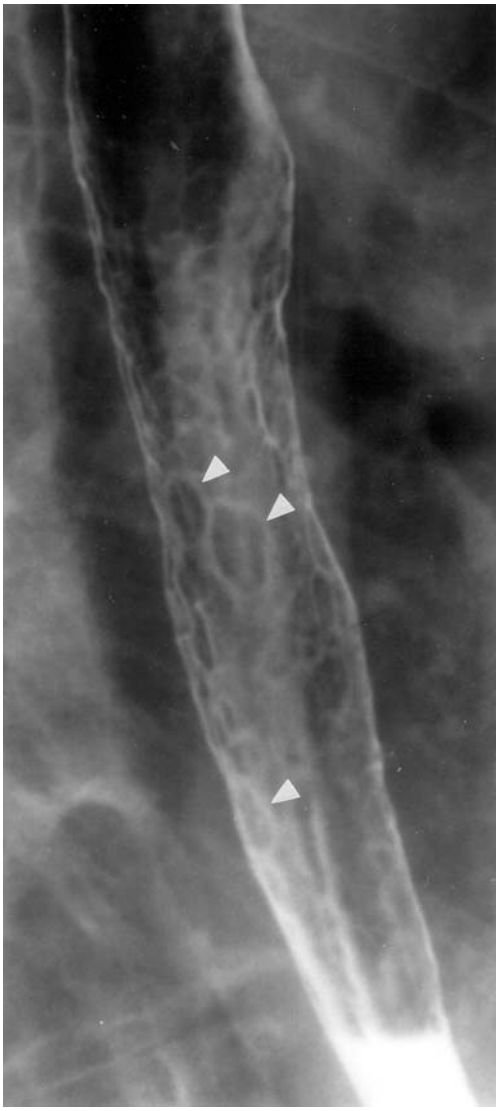

Fig. 2. Reflux esophagitis with pseudomembranes. There are multiple discrete plaquelike lesions (arrowheads) representing pseudomembranes and exudates associated with severe reflux esophagitis. The plaquelike lesions of *Candida* esophagitis could produce similar radiographic findings

Other patients with reflux esophagitis may have solitary ulcers in the distal esophagus at or adjacent to the gastroesophageal junction (*Fig. 5*) [34]. These "marginal" ulcers can be recognized en face as discrete collections of barium but are best visualized when the ulcers are projected in profile beyond the normal contour of the esophagus. In one study, about 70% of these ulcers were found to be located on the posterior esophageal wall [34]. Because GER often occurs dur-ing sleep, it has been postulated that patients who sleep primarily in the supine position are more likely to develop posterior wall ulcers as a result of prolonged exposure to refluxed acid that pools by gravity on the dependent or posterior esophageal wall, causing maximal injury in this location [34].

Thickened folds

Reflux esophagitis may also be manifested on barium studies by thickened longitudinal folds as a result of edema and inflammation that extend into the submucosa (*Fig. 6*) [29]. These folds may have a smooth or irregular contour, occasionally mimicking the appearance of esophageal varices [35]. In general, thickened folds should be recognized as a nonspecific finding of esophagitis resulting from a host of causes. Other patients with chronic reflux esophagitis may have a single prominent fold that arises in the region of the gastric cardia and extends upward into the distal esophagus as a smooth, polypoid protuberance, also known as an inflammatory esophagogastric polyp (*Fig. 7*) [36]–[38]. Because these lesions have no

Fig. 3. Reflux esophagitis with ulceration. Several tiny ulcers (arrows) are seen in the distal esophagus above the gastroesophageal junction

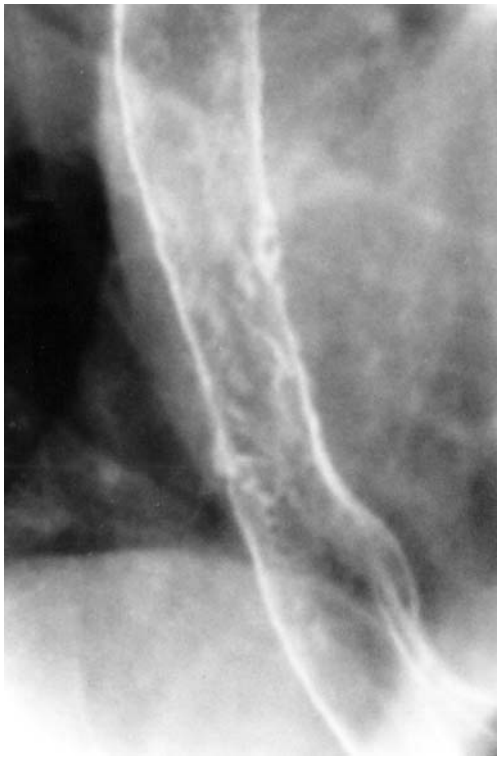

Fig. 4. Reflux esophagitis with extensive ulceration. Multiple ulcers of varying sizes are seen throughout the distal third of the esophagus (Reproduced with permission from [33])

malignant potential, endoscopy is not warranted when barium studies reveal typical findings of an inflammatory polyp in the distal esophagus at or abutting the gastroesophageal junction.

Multiple transverse folds may also be found in patients with GERD, an appearance also known as the "feline" esophagus because transverse esophageal folds are normally found in cats [39], [40]. The folds tend to be closely spaced and completely traverse the circumference of the esophagus (*Fig. 8*). These delicate transverse striations occur as a transient phenomenon resulting from contraction of the longitudinally oriented muscularis mucosae [41]. Transverse folds are often observed in patients with GER, but this finding alone does not indicate the presence of esophagitis [40].

Advanced findings

In advanced reflux esophagitis, extensive ulceration, edema, and spasm may cause the esophagus to have a grossly irregular contour with serrated or spiculated margins and loss of distensibility (*Fig. 9*). Occasionally, the narrowing and deformity associated with

Fig. 5. Reflux esophagitis with a solitary ulcer. A large, relatively flat ulcer (arrow) is present on the right posterolateral wall of the distal esophagus (Reproduced with permission from [33])

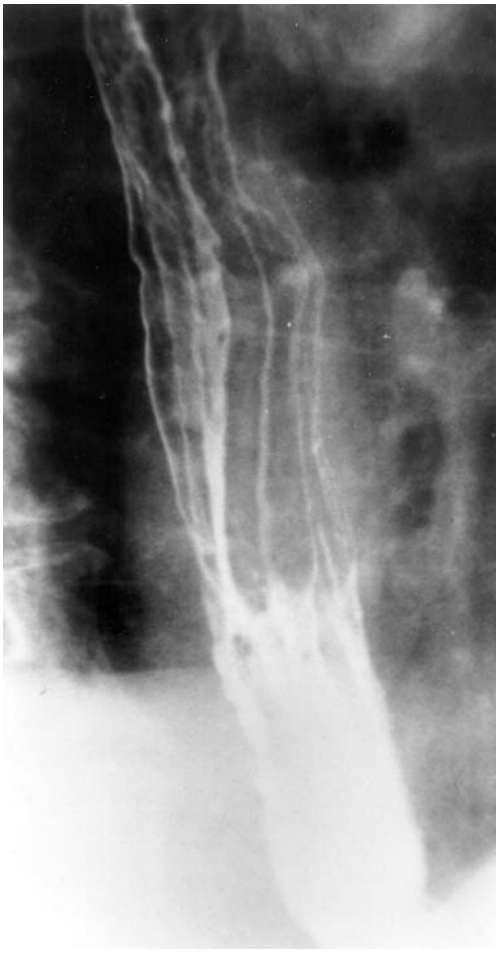

Fig. 6. Reflux esophagitis with thickened folds. Diffusely thickened folds are seen in the thoracic esophagus. This is a nonspecific finding of esophagitis due to a host of causes (Reproduced with permission from [33])

severe esophagitis can mimic the appearance of an infiltrating esophageal carcinoma, so endoscopy and biopsy may be required for a definitive diagnosis.

Peptic scarring

Strictures

As the esophagitis heals, localized scarring may be manifested on barium studies by flattening, puckering, or sacculation of the adjacent esophageal wall, often associated with the development of radiating folds (*Fig. 10*). Further scarring can lead to the development of circumferential strictures, also known as "peptic" strictures. The vast majority of these strictures are located in the distal esophagus above a hiatal hernia. Because many patients with GER or mild reflux esophagitis do not have an associated hiatal hernia, it has been postulated that scarring from reflux esophagitis leads not only to circumferential narrowing of the distal esophagus but also to longitudinal scarring and shortening with subsequent hernia formation [16]. Whatever the explanation, a

Fig. 7. Reflux esophagitis with an inflammatory esophagogastric polyp. There is a prominent fold (straight arrows) that extends from the gastroesophageal junction into the distal esophagus, terminating as a smooth polypoid protuberance (curved arrow). This lesion has the typical appearance and location of an inflammatory esophagogastric polyp (Reproduced with permission from [33])

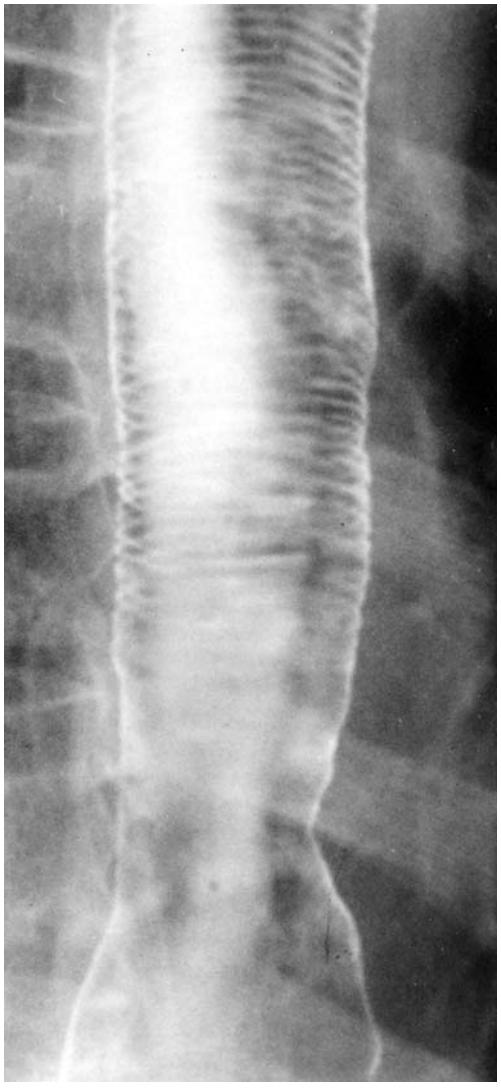

Fig. 8. Feline esophagus. Multiple transverse folds or striations are seen in the esophagus. Note how the folds are closely spaced and extend completely across the circumference of the esophagus. This appearance should be differentiated from the fixed transverse folds associated with scarring from reflux esophagitis, as shown in *Fig. 15* (Reproduced with permission from [33])

hiatal hernia is found on barium studies in more than 95% of patients with peptic strictures [42]. When a hiatal hernia is not present in patients with distal esophageal strictures, the possibility of malignant tumor therefore should be considered as a possible cause of these strictures.

Peptic strictures often appear as concentric areas of smooth, tapered narrowing (*Fig. 11*), but some patients can have short, ringlike strictures (*Fig. 12*) that are difficult to differentiate from Schatzki rings at the gastroesophageal junction (see later section on Schatzki rings). Asymmetric scarring can also lead to asymmetric narrowing with focal sacculation or ballooning of the esophageal wall between areas of fibrosis (*Fig. 13*). Finally, peptic strictures can be associated with the development of esophageal intramural pseudodiverticula (*Fig. 14*) [43]. The pseudodiverticula typically appear as tiny collections of barium "floating" outside the wall of the esophagus without any apparent communication with the lumen, whereas true ulcers are almost always seen to communicate directly with the lumen. When there is marked irregularity, flattening, or nodularity of one or more walls of the stricture, endoscopy and biopsy should be performed to rule out malignant tumor as the cause of these findings.

Fig. 9. Advanced reflux esophagitis. The distal esophagus has an irregular, serrated contour and loss of distensibility as a result of ulceration, edema, and spasm associated with severe reflux esophagitis

Accurate detection of peptic strictures on barium studies requires continuous drinking of low-density barium in the prone position to optimally distend the lower esophagus and demonstrate subtle areas of narrowing that cannot be visualized on upright double-contrast views. With careful biphasic technique, esophagography has a sensitivity of almost 95% in detecting peptic strictures and my even reveal strictures that are missed at endoscopy [44], [45].

Scarring from reflux esophagitis can also lead to longitudinal shortening of the esophagus and the development of fixed transverse folds, producing a characteristic "stepladder" appearance caused by pooling of barium between the folds (*Fig. 15*) [46]. These fixed transverse folds should be differentiated on barium studies from the thin transverse folds (also known as the "feline" esophagus) often seen as a transient finding in patients with GER (see *Fig. 8*) [39], [40].

Schatzki rings

A Schatzki ring was originally described by Schatzki himself as a symptomatic lower esophageal ring that caused dysphagia [47]. The pathogenesis of these rings is uncertain. Some investigators favor a congenital origin, but the rarity of symptoms before 50 years of age tends to refute this theory [48]. Others believe that a Schatzki ring represents an annular, ringlike stricture caused by scarring from reflux esophagitis [49], [50]. This theory is supported by a study showing that Schatzki rings progressed or underwent transformation into true peptic strictures on serial radiologic examinations [49].

A Schatzki ring usually appears on barium studies as a thin (1–3 mm in height), weblike (less than 13 mm in diameter) constriction at the gastroesophageal junction, almost always above a hiatal hernia (*Figs. 16A* and *17A*) [47], [51], [52]. Except for its smaller caliber, a Schatzki ring therefore has the same appearance and location as an asymptomatic mucosal ring. Almost all rings less than 13 mm in diameter cause dysphagia [52], so they may be classified as

Schatzki rings on the basis of the radiographic findings. However, some rings between 13 and 20 mm in diameter may also cause symptoms [52], so the diagnosis of a Schatzki ring requires some knowledge of the clinical history in these patients.

Like other types of narrowing in the distal esophagus, Schatzki rings are visualized on barium studies only if the lumen above and below the ring is distended beyond the caliber of the ring. As a result, single-contrast views of the distal esophagus with the patient in the prone position may demonstrate rings that are not visible, even in retrospect, on upright double-contrast views from the same examination (*Fig. 16B*). In fact, studies have shown that when biphasic barium examinations are performed, prone single-contrast views of the esophagus are more sensitive for detecting Schatzki rings than upright double-contrast views [53] and may even detect rings that are missed at endoscopy [54].

Another potential pitfall in the detection of Schatzki rings on barium studies results from overlap of the distal esophagus and adjacent hiatal hernia tangential to the X-ray beam. This overlap phenomenon may obscure the region of the gastroesophageal junction on esophagrams performed with the patient in the prone position, preventing visualiza-

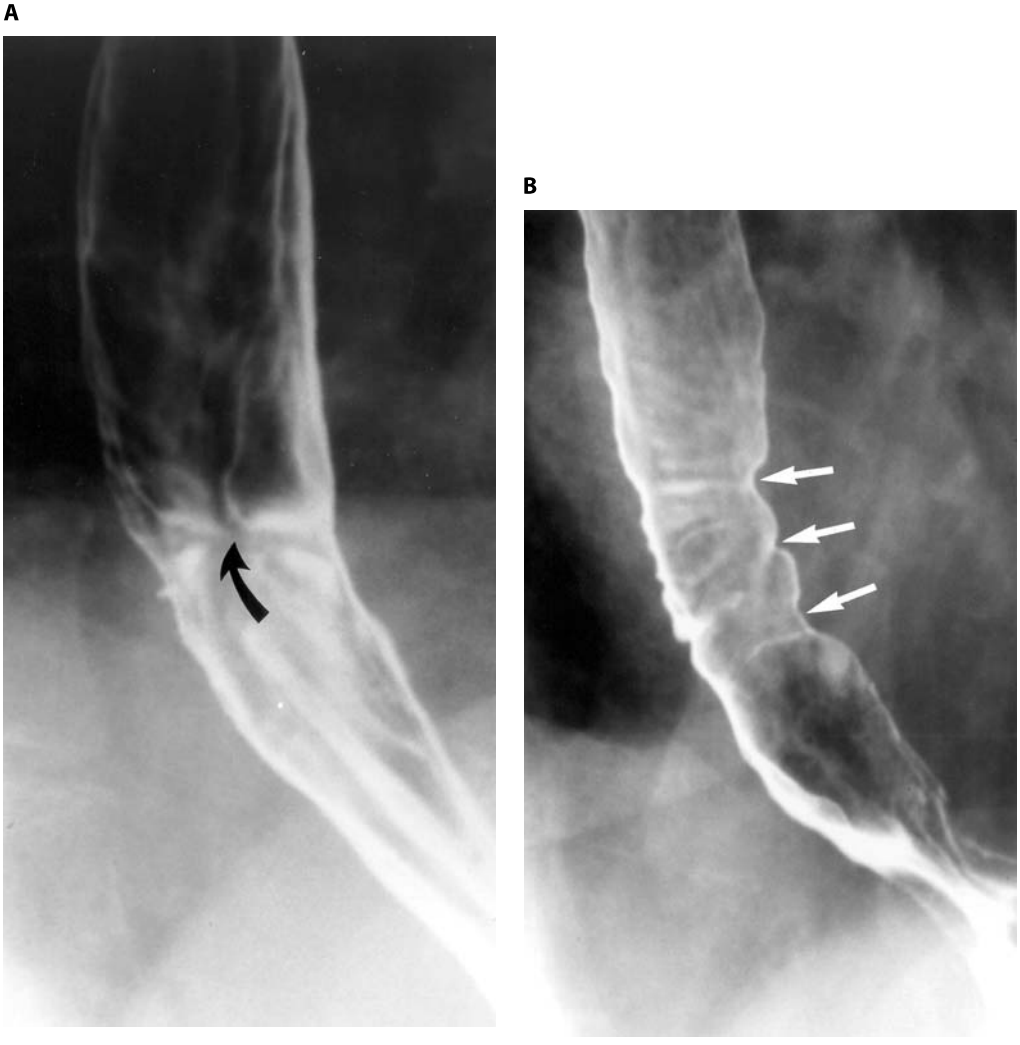

Fig. 10. Peptic scarring in distal esophagus. (**A**) Radiating folds (arrow) are seen in the distal esophagus without associated luminal narrowing. (Reproduced with permission from [30]); (**B**) Note flattening and deformity of one wall (arrows) of the distal esophagus with folds radiating toward the site of scarring in another patient

tion of symptomatic lower esophageal rings (*Fig. 17B*) [55]. When this phenomenon occurs, additional images should be obtained when minimal or no overlap of the distal esophagus and adjacent hiatal hernia is present, improving detection of these rings (see *Fig. 17A*).

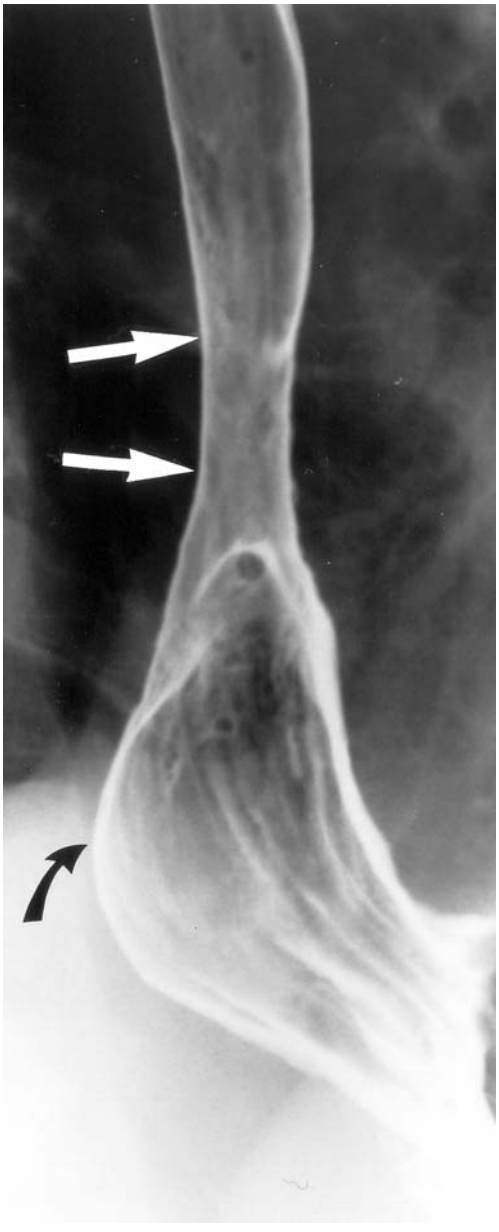

Fig. 11. Peptic stricture. A smooth, tapered area of concentric narrowing (white arrows) is seen in the distal third of the esophagus above a hiatal hernia (black arrow) (Reproduced with permission from [33])

Barrett's esophagus

Barrett's esophagus is a well-recognized entity in which there is progressive columnar metaplasia of the lower esophagus due to long-standing gastroesophageal reflux and reflux esophagitis [56]. This condition is important because it is associated with an increased risk of developing esophageal adenocarcinoma via a well-established dysplasia-carcinoma sequence [57]. During the past decade, revised histopathologic criteria have been developed for this condition in which patients with Barrett's esophagus are classified as

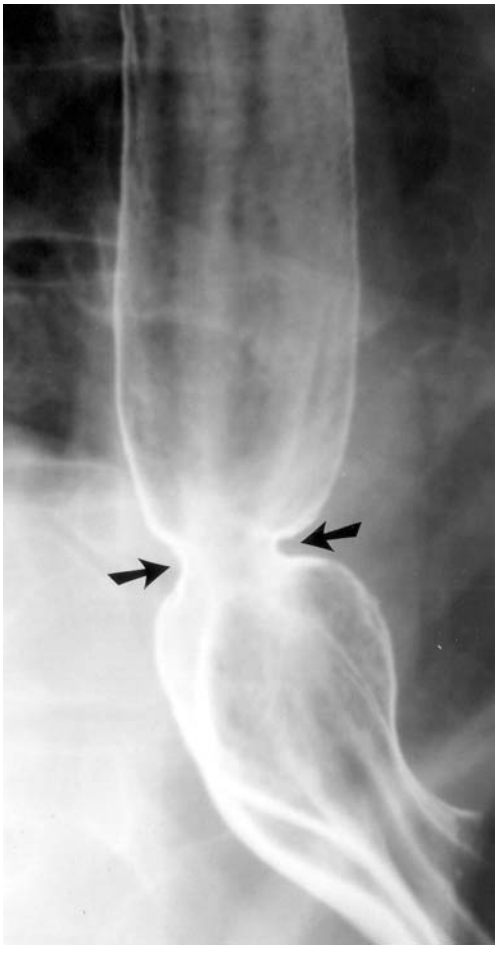

Fig. 12. Ringlike peptic stricture. A short segment of ringlike narrowing (arrows) is seen in the distal esophagus directly above a hiatal hernia. The narrowed segment closely resembles the Schatzki rings shown in *Figs. 16A* and *17A*. However, note asymmetry and slightly greater length of the ringlike peptic stricture in *Fig. 12*

having either "long-segment" (i.e., extending more than 3 cm from the gastroesophageal junction) or "short-segment" (i.e., extending 3 cm or less from the gastroesophageal junction) disease based on the extent of columnar metaplasia in the distal esophagus [58], [59]. Long-segment Barrett's esophagus is thought to be associated with a greater risk of developing esophageal adenocarcinoma and, hence, a greater need for endoscopic surveillance [57], [60], [61]. The radiographic findings in long-segment and short-segment Barrett's esophagus are considered separately in the following sections.

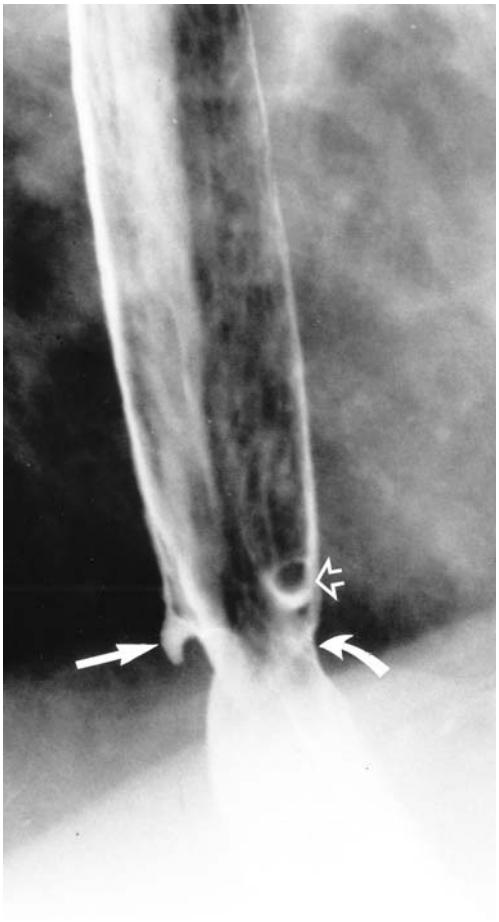

Fig. 13. Peptic stricture with sacculations. There is asymmetric narrowing (curved arrow) of the distal esophagus with focal outpouchings or sacculations en face (open arrow) and in profile (straight arrow) due to outward ballooning of the wall between areas of fibrosis. Note how these sacculations have a more rounded appearance than true ulcers

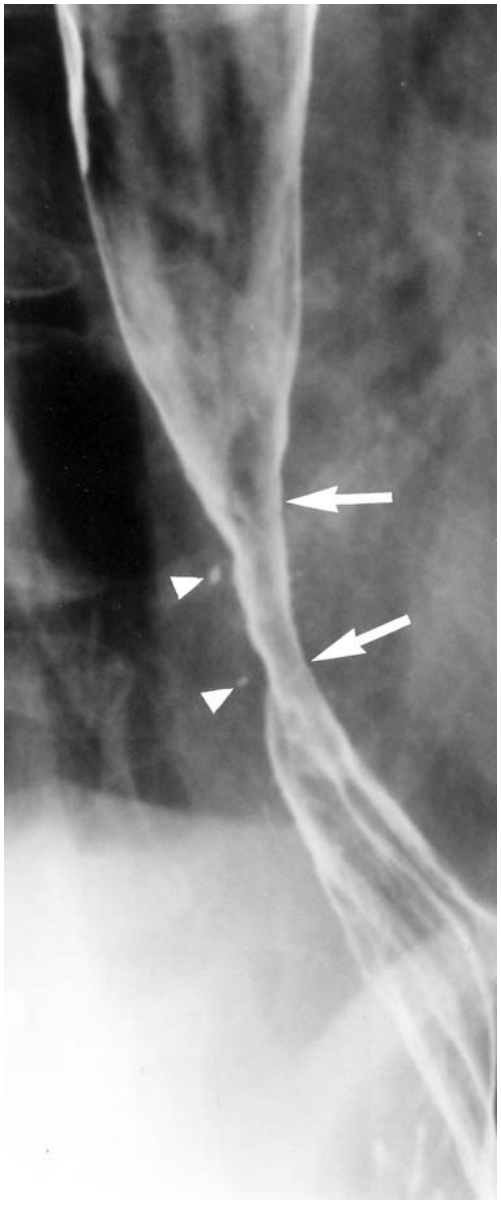

Fig. 14. Peptic stricture with esophageal intramural pseudodiverticulosis. A smooth, tapered segment of concentric narrowing (arrows) is present in the distal esophagus. Barium is also seen in several tiny pseudodiverticula (arrowheads) abutting the stricture. Note how the pseudodiverticula appear to be "floating" outside the wall of the esophagus without any apparent communication with the lumen, a characteristic feature of these relatively innocuous structures (Reproduced with permission from [30])

Long-segment Barrett's esophagus

The classic radiologic features of long-segment Barrett's esophagus consist of a midesophageal stricture (*Fig. 18*) or ulcer, often associated with a sliding hiatal hernia and gastroesophageal reflux [62]–[64]. These strictures or ulcers are thought to be located in the proximal zone of columnar metaplasia at or near the transposed squamocolumnar mucosal junction [63]. However, strictures are actually more common in the distal esophagus in patients with Barrett's esophagus, so most cases do not fit the classic description of a high stricture or ulcer [65]–[67]. A reticular mucosal pattern has also been described as a relatively specific sign of long-segment Barrett's esophagus on double-contrast esophagrams, particularly if located adjacent to the distal aspect of a midesophageal stricture (*Fig. 19*) [68]. This reticular pattern is characterized by innumerable tiny, barium-filled grooves, resembling the areae gastricae found on double contrast studies of the stomach. However, a reticular mucosal pattern is present on barium studies in only 5–30% of all patients with long-segment Barrett's esophagus [64], [66]–[69].

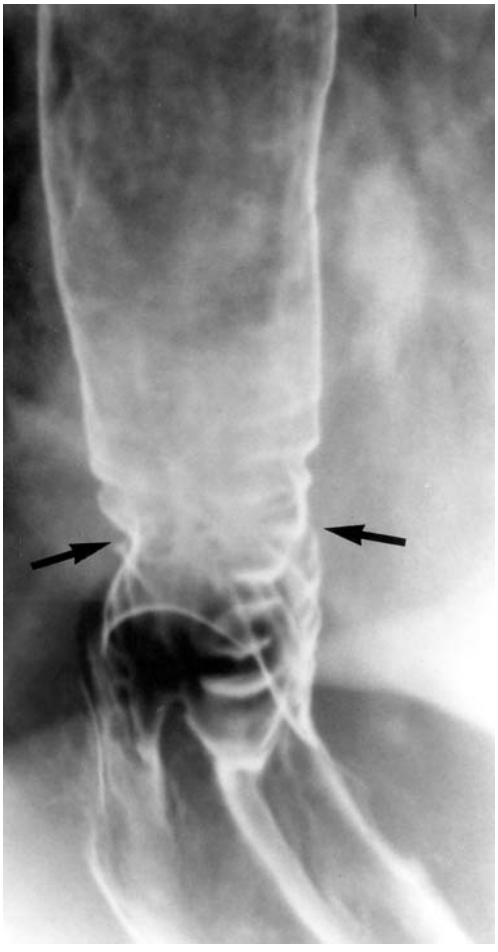

Fig. 15. Peptic stricture with a "stepladder" sign. A mild peptic stricture (arrows) is present in the distal esophagus above a hiatal hernia. In addition, horizontal collections of barium are seen trapped between multiple fixed transverse folds, producing a characteristic stepladder appearance. These folds are further apart and less circumferential than the delicate transverse striations of the feline esophagus shown in *Fig. 8* (Reproduced with permission from [46])

Other morphologic findings of reflux disease, such as hiatal hernias, gastroesophageal reflux, reflux esophagitis, and peptic strictures, can be detected on double-contrast studies in the vast majority of patients with long-segment Barrett's esophagus [69], [70], but these findings frequently occur in patients with uncomplicated reflux disease. Thus, those radiographic findings that are relatively specific for Barrett's esophagus are not sensitive, and those findings that are more sensitive are not specific. As a result, double-contrast esophagography has traditionally been thought to have limited value for diagnosing Barrett's esophagus in patients with known or suspected gastroesophageal reflux disease.

In 1988, Gilchrist et al [70] introduced a novel approach for the diagnosis of Barrett's esophagus on double-contrast esophagography by stratifying patients based on the following radiologic criteria: patients were classified at high risk for Barrett's esophagus if double-contrast images revealed a high stricture or ulcer or a reticular mucosal pattern; patients were classified at moderate risk if the images revealed a distal stricture or reflux esophagitis; and patients were classified at low risk if the images revealed a normal-appearing esophagus. The vast majority of patients classified at high risk and approximately 15% classified at moderate risk for Barrett's esophagus on double-contrast esophagrams were found to have this condition [70]. Conversely, less than 1% of patients classified at low risk for Barrett's esophagus because of the absence of esophagitis or strictures were found to have this condition [70]. Other investigators have also found morphologic evidence of reflux esophagitis and/or peptic strictures on double-contrast esophagrams in 97% of all patients with long-segment Barrett's esophagus [69]. Thus,

esophagitis or peptic scarring severe enough to cause Barrett's esophagus can almost always be detected on technically adequate double-contrast examinations.

On the basis of such data, it seems reasonable to conclude that patients who are found to be at high risk for Barrett's esophagus on double-contrast esophagrams because of a midesophageal stricture or ulcer or a reticular mucosal pattern should undergo endoscopy and biopsy for a definitive diagnosis. A larger group of patients are found to be at moderate risk for Barrett's esophagus because of reflux esophagitis or peptic strictures in the distal esophagus, so clinical judgment should be used regarding the decision for endoscopy in this group based on the severity of symptoms as well as the age and overall health of the patients (i.e., whether they are reasonable candidates for endoscopic surveillance). However, most patients are found to be at low risk for Barrett's esophagus because of the absence of esophagitis or strictures, and the risk of Barrett's esophagus is so low in this group that endoscopy does not appear to be warranted. Thus, the major value of double-contrast esophagography is its ability to separate patients into these various risk groups for Barrett's esophagus to determine the relative need for endoscopy and biopsy [70].

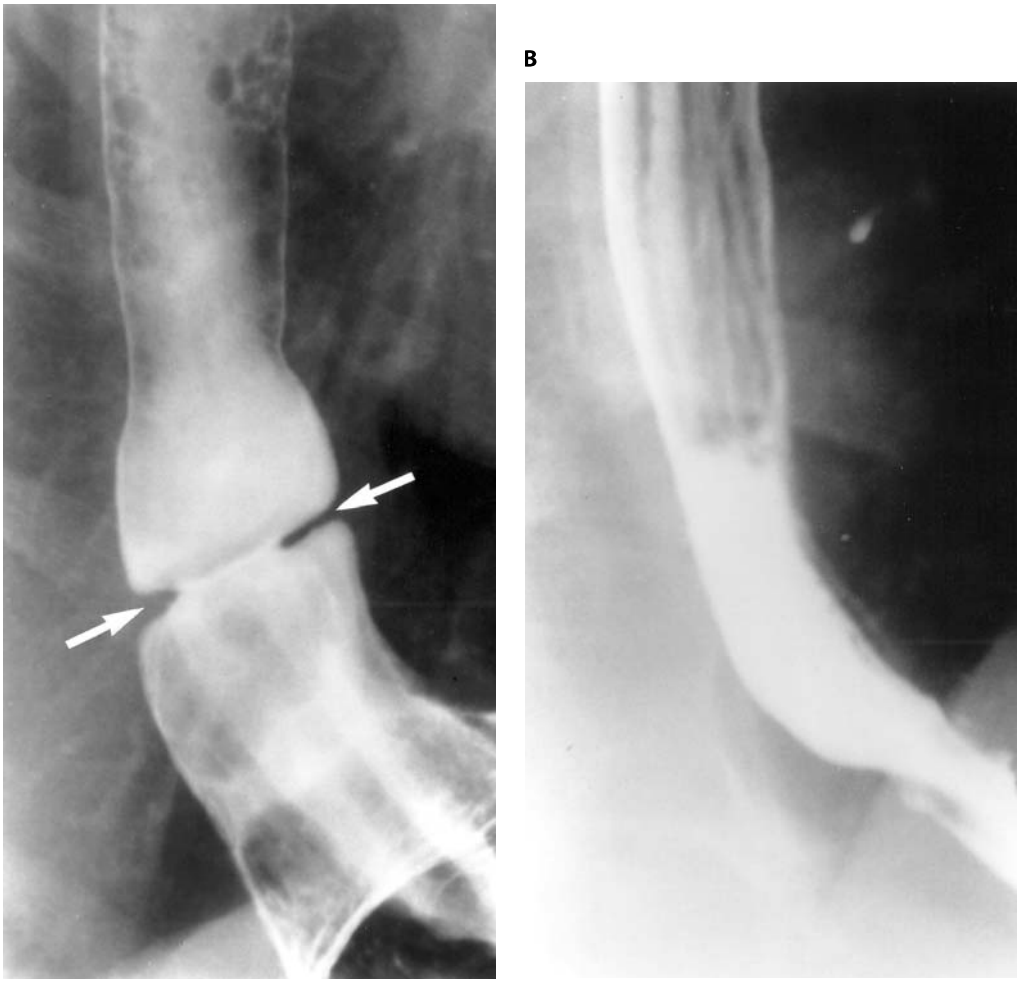

Fig. 16. Schatzki ring seen on prone view of esophagus. (**A**) Prone single-contrast view shows a smooth, symmetric ringlike constriction (arrows) (also known as a Schatzki ring) in the distal esophagus above a hiatal hernia; (**B**) Upright double-contrast view from the same examination shows no evidence of a ring in the distal esophagus because of inadequate distention of this region

Short-segment Barrett's esophagus

Although the radiographic features of long-segment Barrett's esophagus have been well documented [62]–[70], much less is known about the findings in short-segment Barrett's esophagus. In a recent study by Yamamoto et al [71], 70% of patients with short-segment Barrett's esophagus had morphologic evidence of esophagitis and/or peptic scarring or strictures in the distal esophagus on double-contrast esophagrams (*Figs. 20* and *21*). In this study, all of the patients had disease confined to the distal third of the esophagus on barium studies. In contrast, long-segment Barrett's esophagus may be manifested by the development of strictures, ulcers, or a reticular mucosal pattern in the midesophagus (see earlier section on long-segment Barrett's esophagus). Thus, patients with long-segment Barrett's esophagus have more specific radiographic findings for this condition than those with short-segment Barrett's esophagus. It should also be recognized that the length of involvement of the distal esophagus by esophagitis or peptic scarring may extend more than 3 cm above the gastroesophageal junction in patients with short-segment Barrett's esophagus [71], so the diseased segment on esophagography does not necessarily correspond to the vertical extent of columnar metaplasia in the esophagus.

Although 70% of patients with short-segment Barrett's esophagus had reflux esophagitis and/or peptic scarring or strictures on double-contrast esophagrams in the study by Yamamoto et al, the remaining 30% had hiatal hernias or gastroesophageal reflux as the only radiographic findings [71]. The absence of reflux esophagitis or peptic strictures on

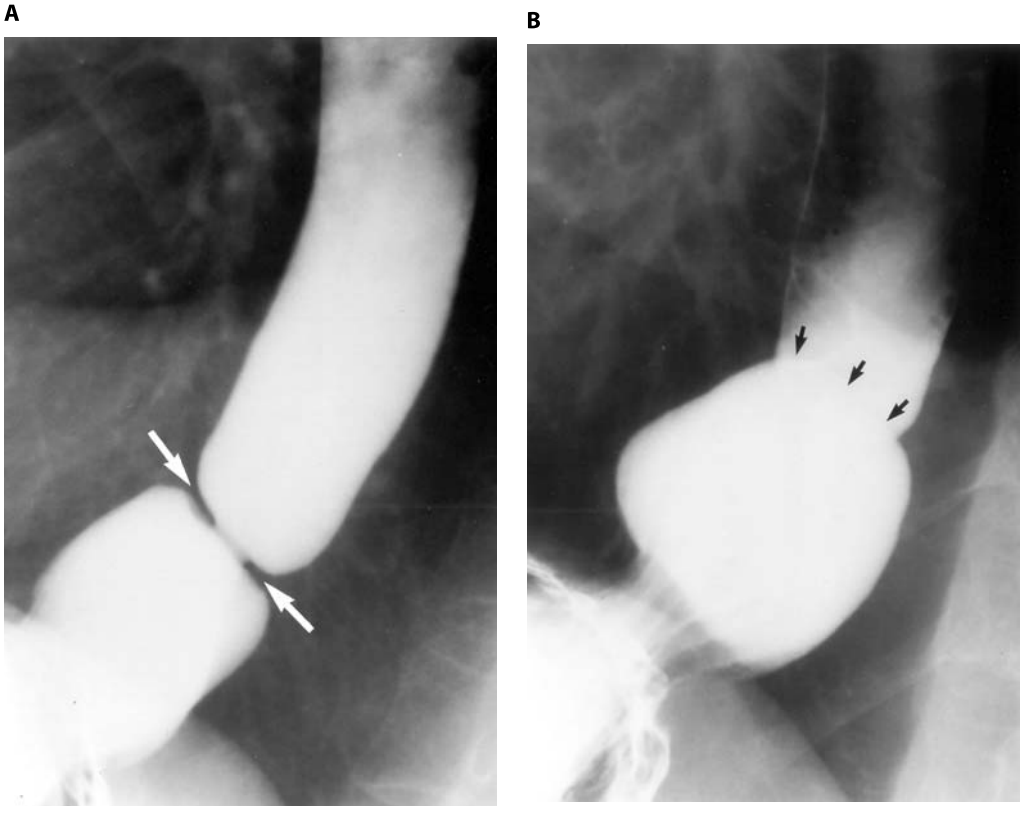

Fig. 17. Schatzki ring obscured by overlap phenomenon. (**A**) Prone single-contrast view shows a tight Schatzki ring (arrows) in the distal esophagus above a hiatal hernia; (**B**) The ring is no longer visible on another prone view from the same examination because of overlap of the distal esophagus and hiatal hernia (arrows) obscuring the region of narrowing. (*Figs. 17A* and *B* reproduced with permission from [55])

double-contrast barium studies therefore does not exclude the possibility of short-segment Barrett's esophagus. In contrast, morphologic findings of reflux disease (reflux esophagitis or peptic strictures) or Barrett's esophagus (midesophageal strictures or ulcers or a reticular mucosal pattern) have been found on double-contrast esophagography in 97–99% of patients with long-segment Barrett's esopha-

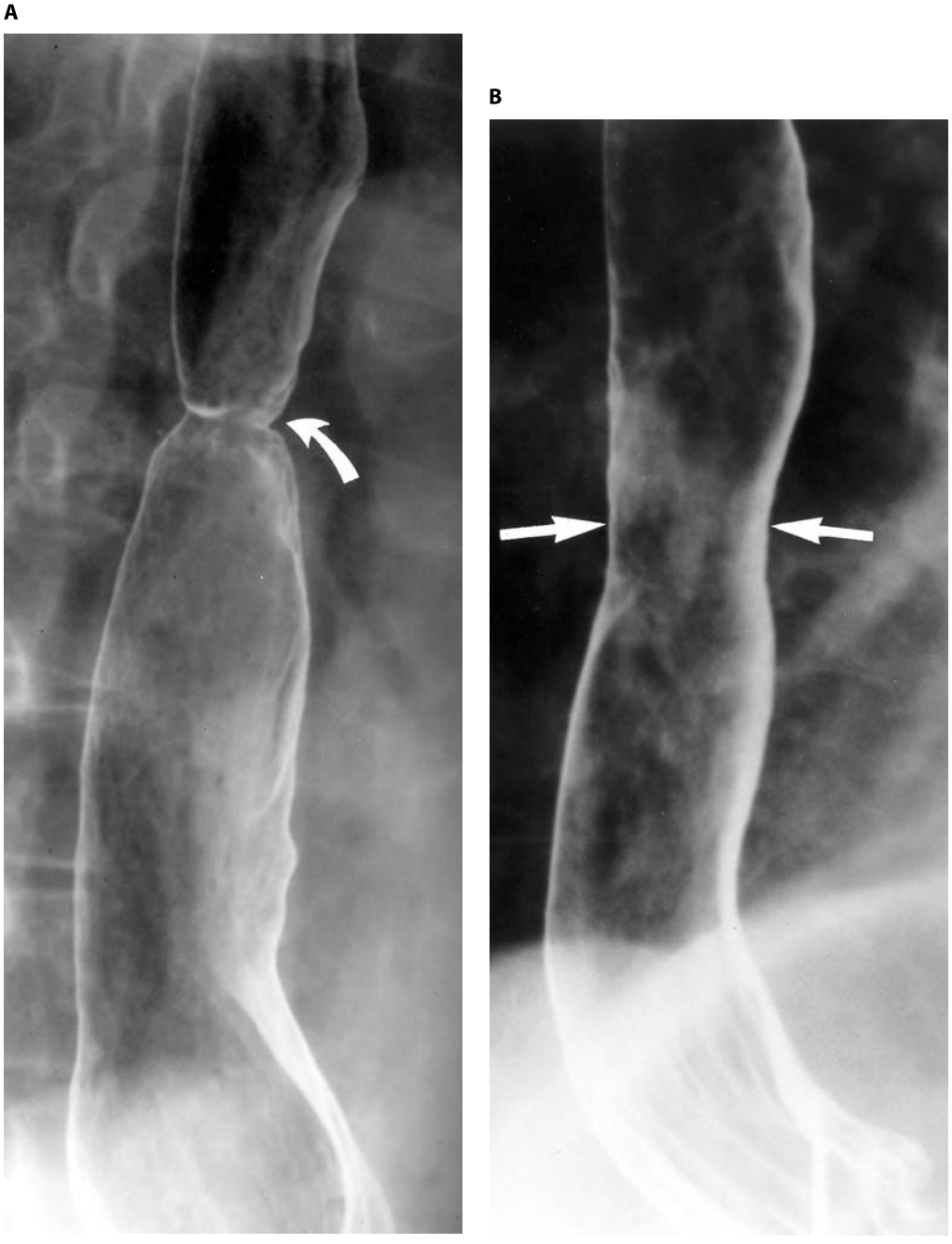

Fig. 18. Long-segment Barrett's esophagus with midesophageal strictures. (**A**) A focal stricture (arrow) is seen in the midesophagus at a considerable distance from the gastroesophageal junction. In the presence of a hiatal hernia and gastroesophageal reflux, this finding is virtually pathognomonic of Barrett's esophagus (Reproduced with permission from [33]); (**B**) A subtler stricture (arrows) is seen in the midesophagus in another patient with Barrett's esophagus

gus [69], [70], so these individuals rarely have a normal-appearing esophagus on double-contrast studies. Thus, patients with short-segment Barrett's esophagus are far more likely to have a normal-appearing esophagus on double-contrast esophagrams than those with long-segment disease. Nevertheless, the clinical importance of this observation remains uncertain because of the lower cancer risk of short-segment Barrett's esophagus compared to that associated with long-segment disease [72]–[74].

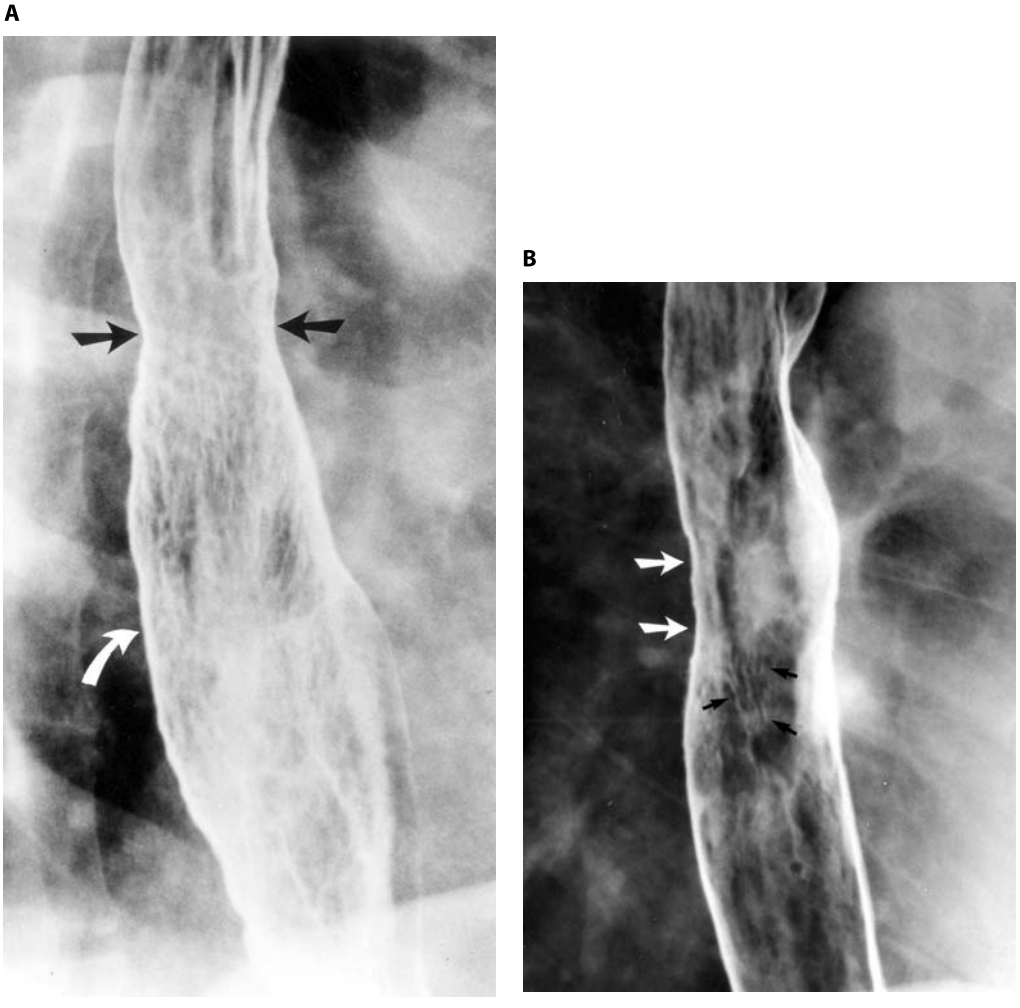

Fig. 19. Long-segment Barrett's esophagus with a reticular pattern of the mucosa. (**A**) A distinctive reticular pattern of the mucosa is seen extending distally a considerable distance (to level of white arrow) from a midesophageal stricture (black arrows) in a patient with Barrett's esophagus; (**B**) There is an early stricture in the midesophagus manifested by slight flattening and retraction of one wall (white arrows) in another patient with Barrett's esophagus. Note the delicate reticular pattern (black arrows) abutting the distal aspect of the stricture (*Figs. 19A* and *B* reproduced with permission from [68])

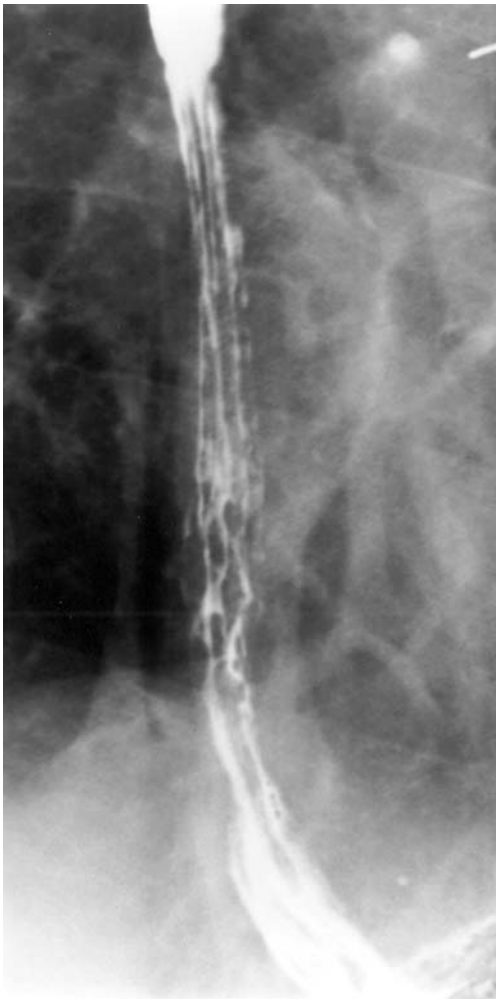

Fig. 20. Short-segment Barrett's esophagus with reflux esophagitis. Thickened, irregular folds are seen in the distal half of the thoracic esophagus due to reflux esophagitis. Endoscopic biopsy specimens confirmed the presence of esophagitis with short-segment Barrett's esophagus (Reproduced with permission from [71])

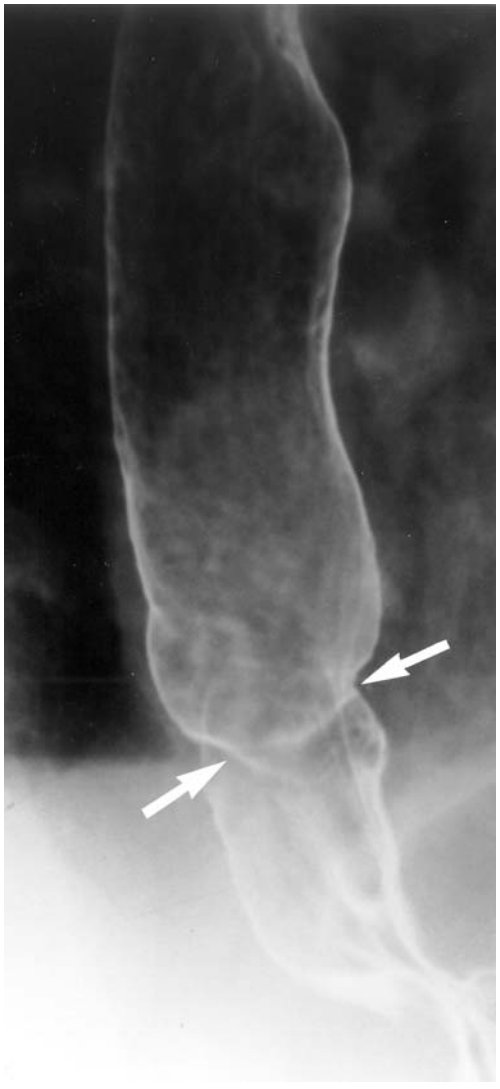

Fig. 21. Short-segment Barrett's esophagus with a peptic stricture. A mild peptic stricture (arrows) is seen in the distal esophagus above a small hiatal hernia. Endoscopic biopsy specimens revealed short-segment Barrett's esophagus (Reproduced with permission from [71])

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