

Usefulness of Barium Studies for Differentiating Benign and Malignant Strictures of the Esophagus

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OBJECTIVE. The purpose of our investigation was to determine the usefulness of barium studies for differentiating benign and malignant strictures of the esophagus.

MATERIALS AND METHODS. A search of radiology and endoscopy files revealed 100 patients with esophageal strictures on barium studies who underwent endoscopy (with endoscopic brushings or biopsy specimens in 57). The images from these barium studies were reviewed by two gastrointestinal radiologists who were unaware of the clinical, endoscopic, and pathologic findings; these observers classified the strictures as having a benign, malignant, or equivocal appearance. The radiographic data were correlated with the endoscopic and pathologic findings to determine the usefulness of barium studies for differentiating benign strictures from malignant tumor.

RESULTS. Of the 100 esophageal strictures detected on barium studies, 75 (75%) had a benign radiographic appearance, 11 (11%) had a malignant appearance, and 14 (14%) had an equivocal appearance. None of the 75 patients with radiographically benign strictures had malignant tumor on endoscopy, which revealed benign strictures in 48 patients and no definite strictures in the remaining 27. Conversely, all 11 patients (100%) with radiographically malignant strictures had malignant tumor on endoscopy. Finally, 13 (93%) of 14 patients with radiographically equivocal strictures had benign strictures without tumor on endoscopy and one (7%) had esophageal carcinoma.

CONCLUSION. Radiographically benign esophageal strictures are not found to be caused by malignant tumor on endoscopy, so these patients can be treated medically before endoscopy or endoscopic dilatation procedures are performed. However, radiographically malignant or equivocal strictures require early endoscopy and biopsy for a definitive diagnosis.

Esophagography is a useful technique for depicting luminal narrowing of the esophagus as a cause of dysphagia, with a reported sensitivity exceeding 95% for the detection of strictures [1–3]. When such strictures are detected on barium studies, many authors of reports in the gastroenterology literature believe that benign causes of narrowing in the esophagus cannot be reliably differentiated from malignant tumor on the basis of the radiographic findings, necessitating further diagnostic workup with endoscopy and brushings or biopsy specimens to rule out esophageal carcinoma [4–12]. However, our impression has been that benign-appearing strictures on esophagography almost always result from benign causes—such as peptic scarring, Barrett's esophagus, or mediastinal irradiation—so endoscopy is not re-

quired to rule out tumor when these strictures have an unequivocally benign appearance on radiography. The purpose of this investigation was to review a large series of patients with radiographically diagnosed esophageal strictures in whom endoscopy was also performed to determine the usefulness of barium studies for differentiating benign and malignant strictures of the esophagus.

Materials and Methods

A computerized search of radiology and endoscopy files at our university hospital from a 45-month period (January 1998–September 2001) revealed 215 patients with esophageal strictures (defined as a persistent segment of luminal narrowing) on barium studies. We excluded Schatzki's rings if the area of narrowing was characterized by a smooth, symmetric ringlike constriction with a length of only 2–4 mm

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[13, 14]. We also excluded strictures involving a postoperative neopharynx or surgical anastomosis such as an esophagogastric anastomosis, but we did not exclude postoperative cases in which esophageal strictures were located at a discrete distance from a surgical anastomosis.

A subsequent computerized search of endoscopy files revealed that 100 of these 215 patients had follow-up endoscopy; endoscopic brushings, biopsy specimens, or both were obtained from the region of the stricture in 57 patients. For the purposes of this study, the endoscopic and pathologic findings were accepted as the gold standard for the differentiation of benign and malignant strictures of the esophagus. These 100 patients therefore comprised our study group. The mean age of the 100 patients in our study group was 61 years (range, 20–86 years). Fifty patients were men, and 50 were women. Seventy-four patients presented with dysphagia.

The barium studies included 52 double-contrast esophagograms, three single-contrast esophagograms, 42 double-contrast upper gastrointestinal tract examinations, and three single-contrast upper gastrointestinal tract examinations. A review of the studies revealed that 81 patients had both double-contrast and single-contrast images of the esophagus (i.e., biphasic examinations), 13 had double-contrast images only, and six had single-contrast images only. The double-contrast images were obtained with the patient in an upright, left posterior oblique position during continuous drinking of a 250% w/v (weight/volume) suspension of barium (E-Z-HD; E-Z-EM, Westbury, NY) after ingestion of an effervescent agent (Baros;

Lafayette Pharmaceuticals, Lafayette, IN). The single-contrast images were obtained with the patient in a prone, right anterior oblique position during continuous drinking of a 50% w/v suspension of barium (Entrobar; Lafayette Pharmaceuticals).

All 100 studies were performed with digital fluoroscopy equipment (Diagnost 76 Plus; Philips, Eindhoven, The Netherlands). The technical quality of the barium studies was graded as excellent in 56 cases (56%), good in 36 (36%), and fair in eight (8%). Of the eight patients with technically fair studies, the quality was limited by inadequate distention of the esophagus in six patients, respiratory motion in one, and aspiration in one.

All images from these 100 barium studies were reviewed in consensus by two experienced gastrointestinal radiologists who were unaware of the clinical, endoscopic, and pathologic findings. The two observers analyzed the morphologic features of the strictures, including location, length, width, symmetry (symmetric vs asymmetric), contour (smooth vs irregular or ulcerated), mucosal surface *en face* (smooth vs nodular or ulcerated), and proximal and distal margins (tapered, abrupt, or shelflike). Tapered margins were characterized by a gradual transition between the stricture and adjacent esophagus; abrupt margins, by a well-defined demarcation; and shelflike margins, by discrete, overhanging edges. The observers also noted the presence or absence of other associated findings, including a hiatal hernia, gastroesophageal reflux, reflux esophagitis, fixed transverse folds, ringlike indentations, webs, and esophageal intramural pseudodiverticula.

After reviewing the images, the two observers jointly classified each stricture as having a benign, malignant, or equivocal appearance. Strictures were classified as benign or malignant if they had unequivocal features of benign disease (e.g., a symmetric area of narrowing with a smooth contour and tapered margins) or malignant tumor (e.g., an asymmetric area of narrowing with an irregular, ulcerated contour and shelflike margins). Strictures that were somewhat asymmetric or had abrupt (but not shelflike) proximal or distal margins were still classified as benign if the strictures had a smooth contour and no other features to suggest malignant tumor. Strictures were classified as having an equivocal appearance if they had mixed features of benign and malignant disease that prevented a confident diagnosis on the basis of the radiographic findings.

Endoscopy reports were reviewed in all 100 cases to determine the endoscopic findings. Endoscopic brushings, biopsy specimens, or both were also obtained in 57 cases, and the pathology reports were reviewed to determine the histopathologic findings. The strictures in these 57 patients were classified as benign or malignant if findings from endoscopic brushings or biopsy specimens were negative or positive for tumor, respectively. All 43 patients in whom endoscopic brushings or biopsy specimens were not obtained had either a normal-appearing esophagus or a benign-appearing stricture on endoscopy; therefore, these strictures were all classified as benign. If endoscopy revealed no evidence of a stricture, then the stricture seen on barium studies was assumed to be a benign stricture that had not been detected on

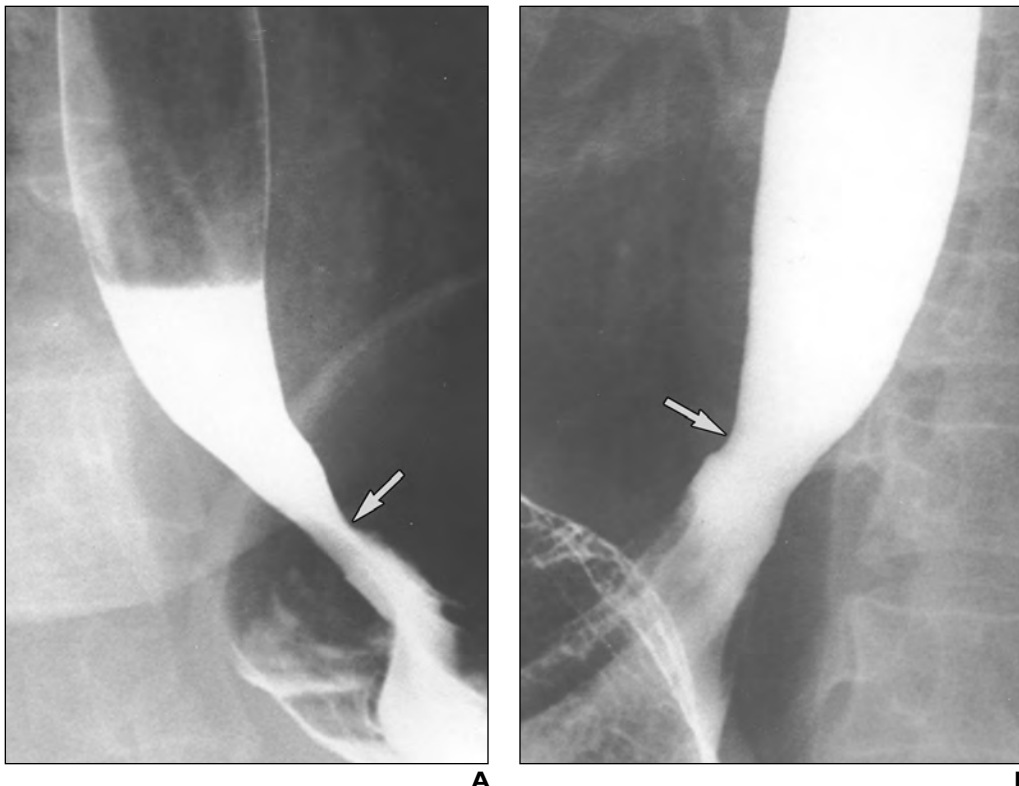


Fig. 1.—67-year-old woman with peptic stricture that was judged to be benign by observers.

A. Left posterior oblique double-contrast esophagogram obtained with patient upright shows benign-appearing stricture (arrow) in distal esophagus. Note that stricture has smooth contour and tapered borders.

B. Right anterior oblique single-contrast esophagogram obtained with patient prone shows smooth, tapered stricture (arrow) in distal esophagus above hiatal hernia. Endoscopy (not shown) revealed peptic stricture, and endoscopic biopsy specimens revealed no evidence of tumor.

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endoscopy because endoscopy may fail to reveal subtle strictures (particularly peptic strictures) that can be detected on barium studies [3].

In theory, an early or subtle esophageal cancer could have been missed on endoscopy in the group without endoscopic brushings or biopsy specimens, but we are aware of no cases in which follow-up barium studies or endoscopy revealed a more advanced esophageal cancer that had not been detected on earlier studies. Thus, the combined endoscopic and pathologic findings were used as the gold standard for benign and malignant strictures of the esophagus. When a malignant stricture of the distal esophagus involved the gastric cardia or fundus, the tumor was thought to arise in the esophagus or stomach, respectively, on the basis of the predominant location of the lesion.

The mean interval between the barium study and endoscopy was 2.9 months (range, 15 days–26 months 2 weeks). Ninety patients (90%) in our study group underwent endoscopy within 6 months of the barium studies. We believe that it was reasonable to include 10 patients in whom the lag between the barium studies and endoscopy was more than 6 months because untreated esophageal carcinoma is known to progress inexorably over time. If anything, a greater lag between the barium studies and endoscopy therefore should increase our confidence in endoscopy as the gold standard for this study.

The radiographic data subsequently were correlated with the endoscopic and pathologic data to determine the usefulness of barium studies for differentiating benign and malignant strictures of the esophagus. Medical records were also reviewed in order to establish the cause of the strictures when there was no evidence of tumor on endoscopy. In all cases, it was noted whether a dilatation procedure (either balloon dilatation or esophageal bougienage) had been performed at the time of endoscopy.

Our institutional review board approved all aspects of this retrospective study and did not require informed consent from patients whose images or records were included in our study.

Results

Radiographic Differentiation of Benign and Malignant Strictures

Of 100 patients with esophageal strictures detected on barium studies, the strictures were classified as having a benign radiographic appearance in 75 (75%) (Figs. 1–4), a malignant appearance in 11 (11%) (Fig. 5), and an equivocal appearance in 14 (14%) (Figs. 6–8). None of the 75 patients with radiographically benign strictures had malignant tumor on endoscopy, which revealed benign strictures in 48 patients and no definite strictures in the remaining 27. Conversely, all 11 patients (100%) with radiographically malignant strictures had malignant tumors on endoscopy. Finally, 13 (93%) of 14 patients with radiographically equivocal

strictures had benign strictures without evidence of tumor on endoscopy, and one (7%) had esophageal carcinoma. Thus, 88 patients (88%) had benign strictures, and 12 (12%) had malignant strictures in the esophagus.

Of the 81 patients with esophageal strictures in whom biphasic examinations were performed, the strictures were visible on single-contrast and double-contrast images of the esophagus in 67 patients (83%), on single-contrast images only in 12 (15%), and on double-contrast images only in two (2%). All 12 strictures that were visible only on single-contrast images obtained with the patient in a prone position were located in the distal esophagus at or near the gastroesophageal junction; these strictures were detected on single-contrast images because of improved distention of the distal esophagus (Fig. 3).

Radiographically Benign Strictures

Of the 75 patients with radiographically benign strictures, 62 (83%) had peptic strictures

(with Barrett's esophagus in three) (Figs. 1–3), four (5%) had radiation strictures (Fig. 4), two (3%) had caustic strictures, two (3%) had congenital esophageal stenosis, one (1%) had a Barrett's stricture, one (1%) had a stricture associated with esophageal intramural pseudodiverticulosis, and three (4%) had strictures of unknown cause. The radiographic features of these 75 benign strictures are summarized in Table 1.

Of the 62 benign-appearing peptic strictures, 38 (61%) involved the distal third of the thoracic esophagus or distal esophagus and gastroesophageal junction, with a mean length of 2.6 cm (range, 0.6–8 cm) and a mean width of 0.9 cm (range, 0.1–1.6 cm) (Fig. 1). The remaining 24 (39%) were characterized by ringlike strictures at the gastroesophageal junction with slightly tapered borders, a mean length of only 0.6 cm (range, 0.4–1.0 cm), and a mean width of 1.1 cm (range, 0.6–1.8 cm) (Figs. 2 and 3). Fifty-eight (94%) of the 62 peptic strictures were associated with hiatal hernias, 47 (76%) with gastroesophageal reflux, eight

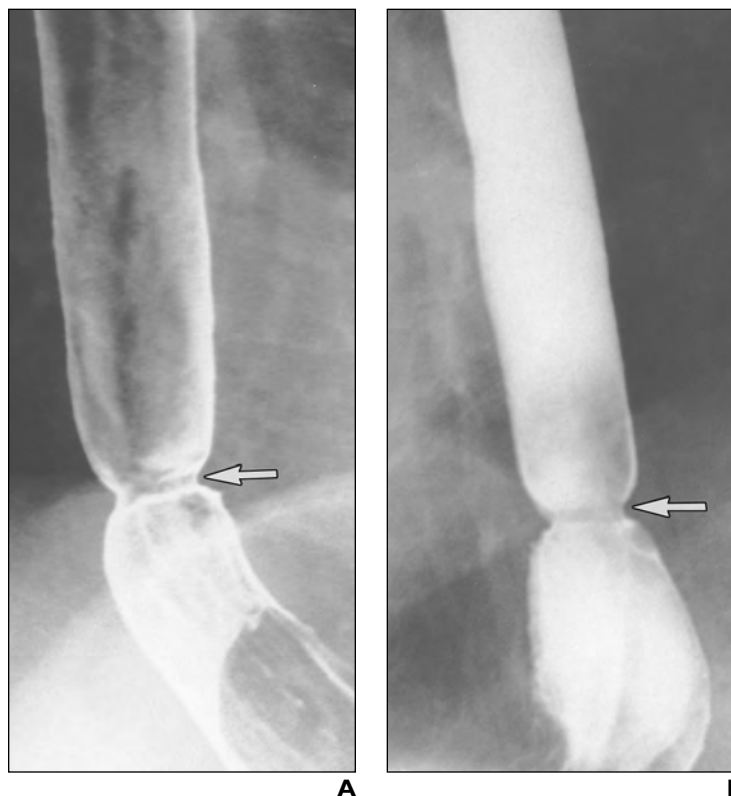


Fig. 2.—57-year-old man with ringlike peptic stricture that was judged to be benign by observers.

A, Left posterior oblique double-contrast esophagogram obtained with patient upright shows benign-appearing stricture as smooth, symmetric ringlike constriction (arrow) with slightly tapered borders at gastroesophageal junction. Note resemblance to Schatzki's ring.

B, Right anterior oblique single-contrast esophagogram obtained with patient prone shows ringlike constriction (arrow) above hiatal hernia. Endoscopy (not shown) revealed ringlike peptic stricture, and endoscopic biopsy specimens revealed no evidence of tumor.

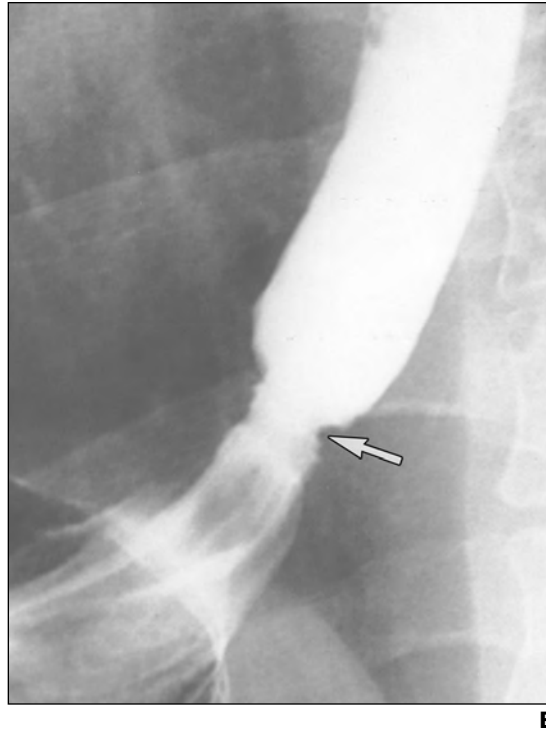


Fig. 3.—53-year-old man with ringlike peptic stricture (seen only on single-contrast esophagogram) that was judged to be benign by observers.
A. Left posterior oblique double-contrast esophagogram obtained with patient upright shows no definite stricture, but distal esophagus is not optimally distended.
B. Right anterior oblique single-contrast esophagogram obtained with patient prone shows benign-appearing ringlike stricture (arrow) at gastroesophageal junction above hiatal hernia. Endoscopy (not shown) revealed short peptic stricture, and endoscopic biopsy specimens revealed Barrett's esophagus without evidence of tumor.

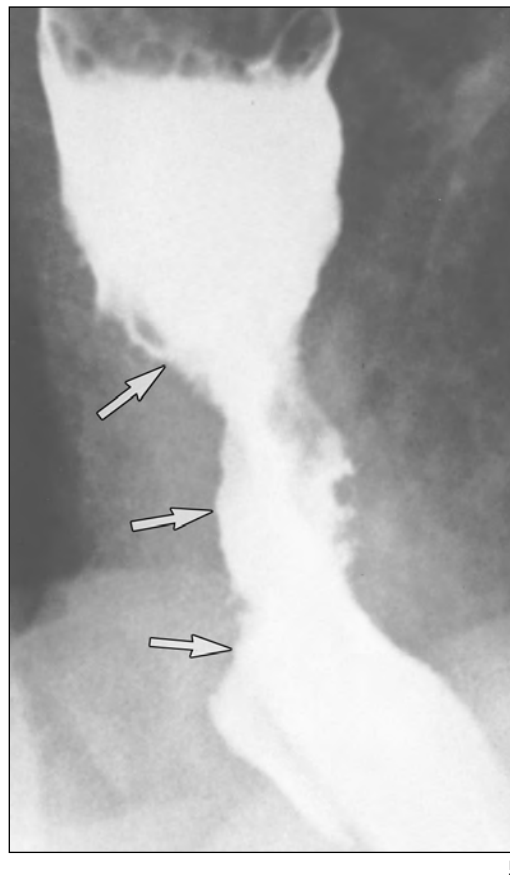
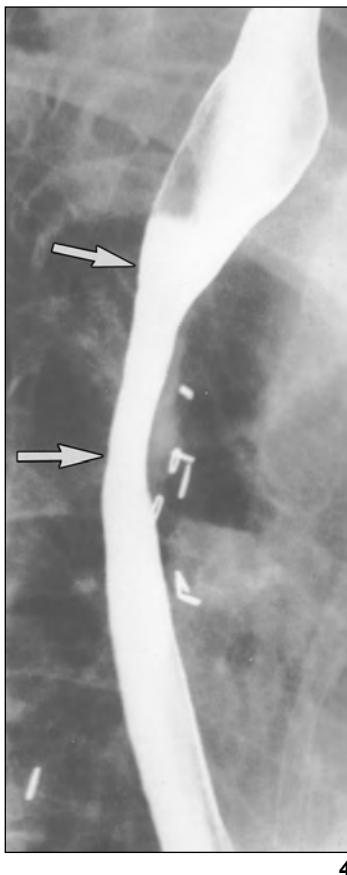


Fig. 4.—62-year-old woman with midesophageal stricture that was judged to be benign by observers. Left posterior oblique double-contrast esophagogram obtained with patient upright shows benign-appearing stricture in mid esophagus as concentric segment of narrowing (arrows) with smooth contour and tapered borders. Endoscopy (not shown) also revealed benign-appearing stricture in mid esophagus, and endoscopic biopsy specimens revealed no evidence of tumor. Because patient had history of radiation therapy for lung carcinoma, this stricture is presumed to have been radiation induced. (Note surgical clips from prior left upper lobectomy.)

Fig. 5.—71-year-old man with distal esophageal stricture that was judged to be malignant by observers. Left posterior oblique double-contrast esophagogram obtained with patient upright shows malignant-appearing stricture (arrows) in distal esophagus. Narrowed segment has markedly irregular contour with areas of nodularity and ulceration. Endoscopic biopsy specimens revealed esophageal adenocarcinoma.

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(13%) with reflux esophagitis, five (8%) with one or more distal esophageal webs, and three (5%) with fixed transverse folds.

All four benign-appearing radiation strictures and both caustic strictures were characterized by symmetric areas of narrowing with smooth contours and tapered proximal and distal margins in the upper or mid esophagus or both (Fig. 4). Both of the strictures presumed to be caused by congenital esophageal stenosis were characterized by symmetric areas of narrowing in the middle third of the thoracic esophagus with distinctive ringlike indentations in the narrowed segments [15]. One patient with Barrett's esophagus had a focal stricture in the mid esophagus, and one patient with esophageal intramural pseudodiverticulosis had a long stricture involving the cervical and upper and middle thirds of the thoracic esophagus.

Endoscopic brushings or biopsy specimens were obtained in 35 (47%) of the 75 patients with radiographically benign strictures. Histopathologic findings included esophagitis in 17 patients (49%), reactive changes in six (17%), Barrett's esophagus in four (11%), and normal-appearing mucosa in eight (23%). Of the 48 cases of definite strictures on endoscopy, 13 (27%) were described as ringlike areas of narrowing or "rings" at the gastroesophageal junction. Of the remaining 27 patients with no definite strictures on endoscopy, 13 (48%) had esophagitis, so it is uncertain in these cases whether apparent strictures detected on barium studies were caused by edema and spasm from esophagitis or whether the strictures were missed on endoscopy.

Thirty-nine (52%) of the 75 patients with radiographically benign strictures under-

went endoscopic dilatation procedures, including balloon dilatation in 27 (69%) and esophageal bougienage in 12 (31%).

Radiographically Malignant Strictures

Of the 11 patients with radiographically malignant strictures (Fig. 5), endoscopic biopsy specimens revealed squamous cell carcinoma of the esophagus in five (46%), adenocarcinoma of the esophagus in four (36%), poorly differentiated carcinoma of the esophagus in one (9%), and gastric carcinoma invading the esophagus in one (9%). The radiographic features of these 11 malignant strictures are summarized in Table 1.

The malignant strictures involved the middle third of the thoracic esophagus in three patients (27%); the distal third in four (37%); the distal third and gastric cardia and fundus in three

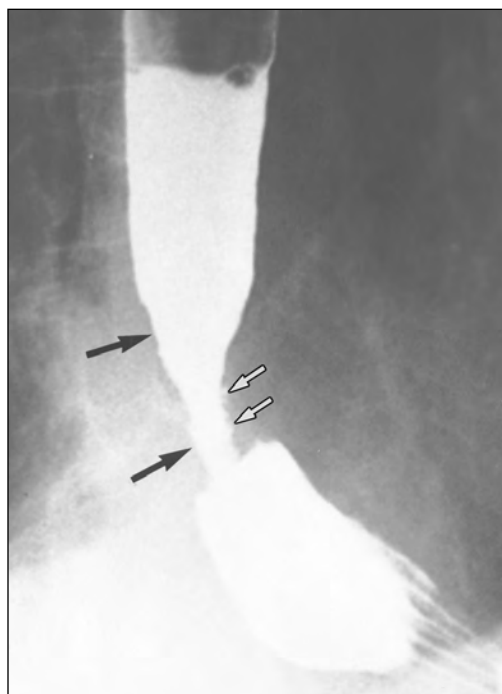


Fig. 6.—55-year-old woman with peptic stricture that was judged to be equivocal by observers. Left posterior oblique double-contrast esophagogram obtained with patient upright shows that stricture (black arrows) in distal esophagus has some benign features with tapered proximal margins and some malignant features with irregular contour and tiny areas of ulceration (white arrows). Endoscopy (not shown) revealed peptic stricture in distal esophagus with associated reflux esophagitis, but endoscopic biopsy specimens revealed no evidence of tumor.

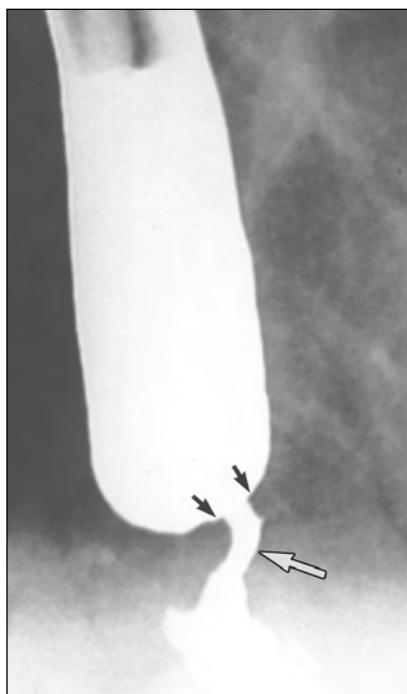


Fig. 7.—67-year-old man with peptic stricture that was judged to be equivocal by observers. Left posterior oblique double-contrast esophagogram obtained with patient upright shows that stricture (white arrow) in distal esophagus has some benign features with tapered distal margins and some malignant features with abrupt proximal margins (black arrows) and marked asymmetry. Endoscopy (not shown) revealed benign peptic stricture in distal esophagus, and endoscopic biopsy specimens revealed Barrett's esophagus without evidence of tumor.



Fig. 8.—58-year-old man with upper esophageal stricture that was judged to be equivocal by observers. Right posterior oblique double-contrast esophagogram obtained with patient upright shows that stricture (white arrow) in upper esophagus has some benign features with tapered distal margins and smooth contour and some malignant features with abrupt proximal margins (black arrows). Endoscopy (not shown) revealed malignant-appearing stricture in upper esophagus, but endoscopic biopsy specimens could not be obtained because of degree of obstruction. This patient was known to have undergone esophagegastrectomy for esophageal carcinoma; therefore, endoscopic findings were attributed to recurrent or metachronous carcinoma.

(27%); and the upper, middle, and distal thirds in one (9%). Three of the tumors were associated with varying degrees of obstruction and one resulted in the development of an esophagobronchial fistula.

Four (36%) of the 11 patients had surgery, and seven (64%) had palliative endoscopic procedures for relief of dysphagia.

Radiographically Equivocal Strictures

Of the 14 patients with radiographically equivocal strictures, nine (64%) had peptic strictures (with Barrett's esophagus in two) (Figs. 6 and 7), two (14%) had radiation strictures, one (7%) had a Barrett's stricture, one (7%) had a drug-induced stricture from potassium chloride, and one (7%) had esophageal carcinoma (Fig. 8). The radiographic features of these 14 equivocal strictures are summarized in Table 1.

The equivocal strictures were located in the cervical esophagus in one patient (7%), the upper third of the thoracic esophagus in two

(14%), the middle third of the thoracic esophagus in two (14%), the distal third of the thoracic esophagus in six (43%), and at the gastroesophageal junction in three (22%).

Endoscopic biopsy specimens from 11 patients with radiographically equivocal strictures revealed no evidence of tumor in any of the patients, with inflammatory or reactive changes in five (46%), Barrett's esophagus in three (27%), and normal biopsy specimens in three (27%). In two patients with radiographically equivocal strictures, the esophagus appeared normal at endoscopy, so no biopsy specimens were obtained. In the remaining patient with an equivocal stricture (Fig. 8), endoscopy revealed a malignant-appearing stricture in the upper esophagus, so the stricture was classified as malignant; however, biopsy specimens could not be obtained because of the degree of obstruction.

Ten (71%) of the 14 patients in this group underwent endoscopic dilatation procedures for relief of their dysphagia.

Discussion

Double-contrast esophagography has been shown to have a sensitivity of greater than 95% for detecting esophageal carcinoma [16–18]. Despite these data, many gastroenterologists believe that endoscopy and biopsy are required to rule out malignant tumor in all patients with radiographically diagnosed strictures in the esophagus because of inherent limitations of barium studies in differentiating benign causes of stricture formation from esophageal carcinoma [4–12]. In our blinded retrospective study of 100 patients with esophageal strictures on barium studies, however, 75 (75%) had radiographically benign strictures (Figs. 1–4), and none of these patients had malignant tumor in the esophagus on endoscopy. Conversely, all 11 patients (100%) with radiographically malignant strictures had malignant tumor on endoscopy (Fig. 5). Finally, 13 (93%) of the 14 patients with radiographically equivocal strictures had benign strictures (Figs. 6 and 7), and one (7%) had recurrent or metachronous esophageal carcinoma on endoscopy (Fig. 8).

Our results indicate that patients with radiographically benign strictures in the esophagus are not found to have malignant tumor as the cause of this finding, so endoscopy and biopsy are not required to rule out cancer when esophageal strictures have an unequivocally benign appearance on barium studies. Although most patients with radiographically equivocal strictures are also found to have benign causes of stricture formation, endoscopy and biopsy are warranted for equivocal strictures because of a small risk of malignant tumor in these patients. Finally, patients with radiographically malignant strictures are almost always found to have malignant tumors in the esophagus, so endoscopy and biopsy should be performed for a definitive diagnosis.

As in our series, most benign strictures detected on barium studies are found to be peptic strictures caused by scarring from reflux esophagitis. These peptic strictures are associated with a high prevalence of Barrett's esophagus [19]. Because Barrett's esophagus is a premalignant condition associated with the development of esophageal adenocarcinoma via a sequence of progressively severe epithelial dysplasia [20], patients with peptic strictures often undergo endoscopy and biopsy to confirm the presence of Barrett's esophagus, making these individuals candidates for endoscopic surveillance. However, peptic strictures sometimes contain areas of esophagitis and associated reactive changes that are difficult to differentiate

TABLE 1 Summary of Radiographic Features of Esophageal Strictures Detected on Barium Studies in 100 Patients						
Characteristics of Esophageal Strictures	Appearance of Esophageal Strictures on Barium Study					
	Benign (n = 75 patients)		Malignant (n = 11 patients)		Equivocal (n = 14 patients)	
	No. of Patients	% of Patients	No. of Patients	% of Patients	No. of Patients	% of Patients
Narrowing						
Symmetric	42	56	1	9	4	29
Asymmetric	33	44	10	91	10	71
Proximal margins						
Tapered	70	93	4	36	10	71
Abrupt	5	7	2	18	4	29
Shelflike	0	0	5	46	0	0
Distal margins ^a						
Tapered	63	84	4	36	12	86
Abrupt	12	16	0	0	2	14
Shelflike	0	0	5	46	0	0
Contour						
Smooth	66	88	2	18	3	21
Irregular or ulcerated	9	12	9	82	11	79
Mucosal surface						
Smooth	62	83	1	9	5	36
Nodular or ulcerated	13	17	10	91	9	64
	Mean (cm)	Range (cm)	Mean (cm)	Range (cm)	Mean (cm)	Range (cm)
Length	2.5	0.3–14.4	5.9	1.5–10.8	2.4	0.7–4.8
Width	1	0.1–1.8	0.6	0.1–1.2	0.5	0.2–1.4

^a Distal margins not evaluated for two malignant strictures because of degree of obstruction.

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from dysplasia in Barrett's esophagus on endoscopic biopsy specimens [21]. Because patients with benign-appearing peptic strictures on barium studies are almost never found to have malignant tumor in the esophagus, these patients could receive a trial of therapy with antisecretory agents for several months to heal their underlying esophagitis before endoscopy is performed. Such an approach might improve the diagnostic accuracy of endoscopy for Barrett's esophagus in patients with radiographically benign peptic strictures.

Even in the absence of tumor, symptomatic patients with esophageal strictures may require endoscopic dilatation procedures to relieve their dysphagia. In our study, 49 (56%) of the 88 patients with benign strictures underwent various dilatation procedures. However, many patients with peptic strictures have coexisting reflux esophagitis, and treatment of this esophagitis with antisecretory agents may be as important for relief of dysphagia as a dilatation procedure [22]. In one study of patients with esophagitis and peptic strictures causing dysphagia, endoscopic dilatation procedures were required in only 11 (44%) of 25 patients in whom the esophagitis healed on medical treatment versus all seven (100%) who had persistent esophagitis despite medical treatment [23]. A focal area of decreased distensibility on barium studies can also result from edema and spasm due to reflux esophagitis without actual fibrosis, producing a reversible "pseudosticture" that partly or completely resolves with healing of the underlying esophagitis [24]. Thus, patients with benign-appearing peptic strictures on barium studies could initially receive a trial of antisecretory agents, reserving endoscopic dilatation procedures for those with persistent dysphagia after medical treatment. Our ability to differentiate benign peptic strictures from malignant tumor in the esophagus on barium studies therefore has potential clinical benefit for these patients.

Our findings also show the value of performing biphasic examinations for detecting esophageal strictures (particularly peptic strictures) on barium studies by optimizing distention of the distal esophagus. Of the strictures in our study, 15% were visible only on single-contrast images of the esophagus obtained with the patient prone during continuous drinking of a low-density barium suspension (Fig. 3). Other studies have shown that the use of single-contrast technique improves radiographic diagnosis of peptic strictures and lower esophageal rings [25, 26]. Biphasic barium studies may even permit detection of strictures that are missed on endoscopy.

In our series, 27 (27%) of 100 radiographically diagnosed esophageal strictures were not detected on endoscopy. In an earlier study, endoscopy failed to reveal 12% of peptic strictures greater than 1 cm in caliber that were detected on biphasic esophagograms [3]. Nevertheless, it is possible that some of our patients underwent dilatation procedures at other hospitals in the interval between the barium studies and endoscopy, partly accounting for the discrepancy between the radiographic and endoscopic findings. We also cannot rule out the possibility that some of the apparent strictures detected on barium studies represented false-positive radiographic findings.

Benign peptic strictures classically have been described as smooth, tapered areas of concentric narrowing that range from 1 to 4 cm in length and are almost always located in the distal esophagus above a hiatal hernia [24, 27] (Fig. 1). In our study, however, 24 (39%) of 62 radiographically diagnosed peptic strictures appeared as ringlike areas of narrowing at the gastroesophageal junction with slightly tapered borders and a length of only 0.4–1.0 cm (Figs. 2 and 3). Schatzki's rings may produce similar radiographic findings, but they usually range from 2 to 4 mm in length and have more abrupt borders [13, 14]. These ringlike peptic strictures therefore may be differentiated from true Schatzki's rings by their greater length and more tapered borders. Despite these subtle distinctions, we believe that there is overlap between ringlike peptic strictures and Schatzki's rings detected on barium studies or endoscopy.

Our investigation has a number of limitations. Because this study was a retrospective study of patients with esophageal strictures who underwent both barium studies and endoscopy, there was unavoidable selection bias: patients with more severe symptoms or more suspicious radiographic findings were more likely to undergo follow-up endoscopy. Because patients who did not undergo endoscopy were excluded from our study population, this selection bias probably resulted in a higher frequency of malignant strictures than might be expected in a prospective study of all patients with radiographically diagnosed esophageal strictures. The prevalence of esophageal cancer in the study population represents another potential selection bias because the percentage of equivocal strictures may be greater when there is a high prevalence of malignant tumor.

Ideally, we would have liked to correlate the radiographic findings with the pathologic findings in all cases, but endoscopic brushings or

biopsy often were not performed in patients who had benign-appearing strictures or no definite strictures on endoscopy. We also were surprised by the low prevalence of Barrett's esophagus in our study group: only seven (8%) of 88 patients with benign strictures had pathologically proven Barrett's esophagus. This low prevalence of Barrett's esophagus may be partly related to the fact that endoscopic biopsy specimens were obtained in only 57% of all patients with esophageal strictures. Finally, we recognize that general radiologists with less experience and expertise performing barium studies than dedicated gastrointestinal radiologists may not be able to differentiate benign from malignant strictures of the esophagus with the same degree of confidence as our observers.

In conclusion, we found that radiographically benign strictures in the esophagus are not shown to be caused by malignant tumor on endoscopy, so patients with these findings can be treated medically before endoscopy or endoscopic dilatation procedures are performed. However, patients with radiographically equivocal or malignant strictures require early endoscopy and biopsy for a definitive diagnosis.

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